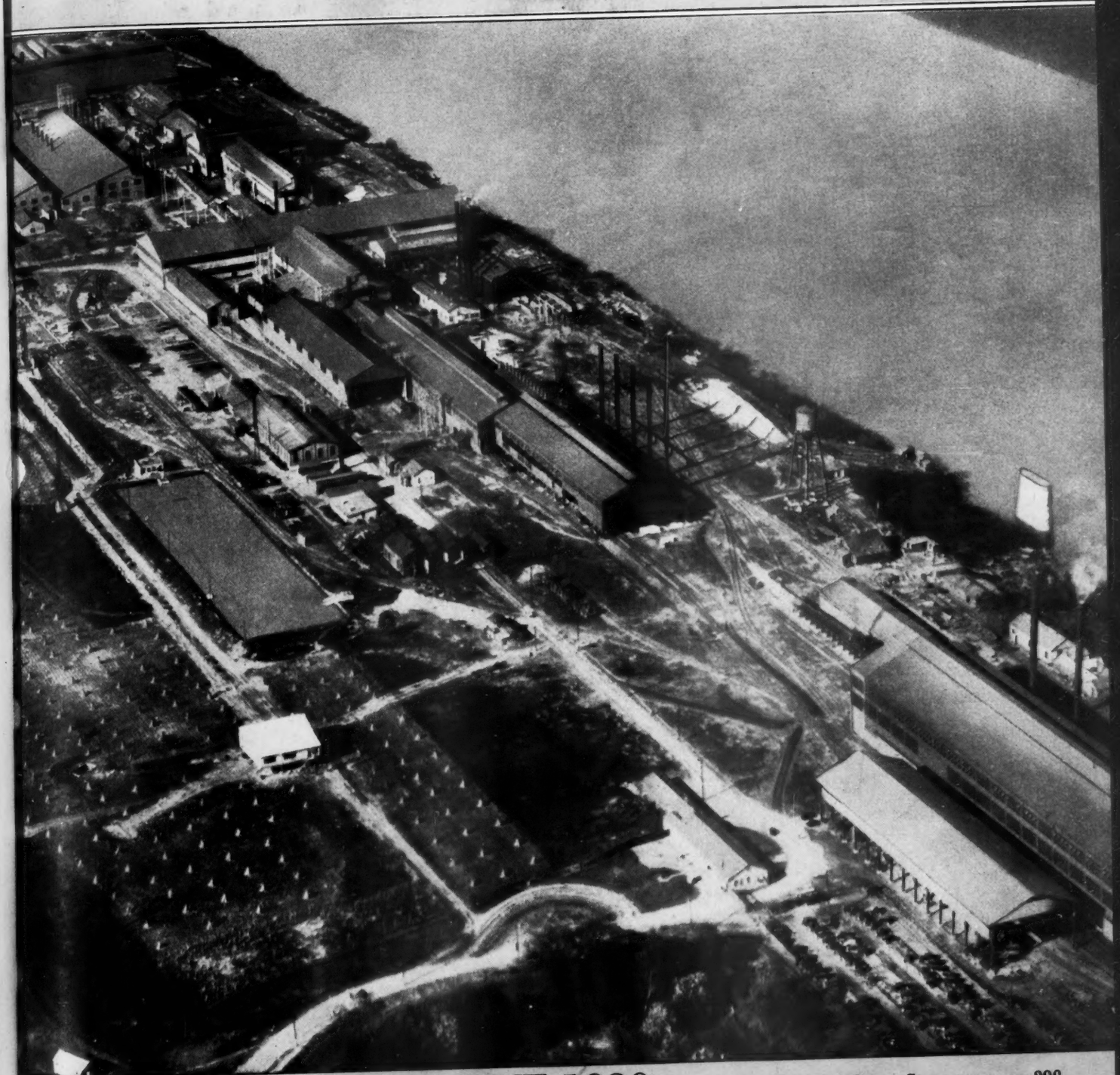
JUN 16 1930

INDUSTRIAL ENGINEERING

MAINTENANCE ENGINEERING
IN PLANTS, MILLS, AND FACTORIES



A McGraw-Hill Publication

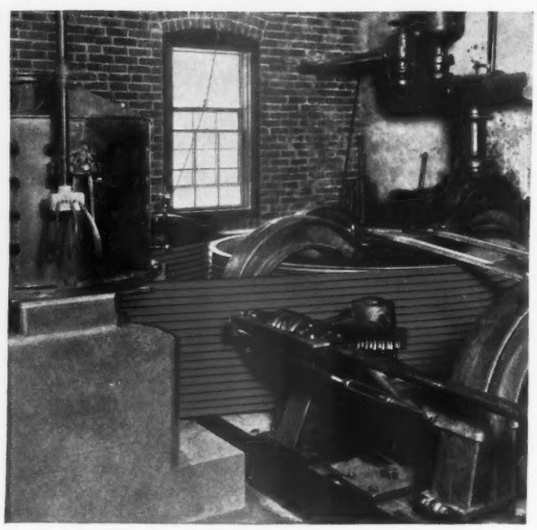
JUNE-1930

For Cover Story see page 290

TEXROPE DRIVES
Give *Continuous* Service with Almost No *Maintenance*

EVERYWHERE the trend is toward Texrope Drive. This short center transmission is always silent. It is clean, yet unaffected by dirt or moisture. Starting and acceleration are smooth . . . no jerks . . . no slip . . . no backlash.

Vibration is absorbed by the Texropes. The motor is protected from shocks. Bearing trouble due to the drive disappears. Continuous operation is assured. Costly shut-downs become a thing of the past.



Texrope is used as a vertical drive with most satisfactory results. This installation is at the Lovejoy Tool Co., Springfield, Vt. The 125 H. P. Texrope is operating a 93 K. W., 60 cycle, 2200 volt Allis-Chalmers induction generator from a water wheel. Only perfectly molded V-Belts can operate properly over sheaves on vertical shafts.

Texrope Drives require no belt dressing . . . no greasing . . . no oiling. There is no wear on the grooved sheaves and almost none on the rubberized-cord belts. Maintenance cost is reduced to a minimum. The belts are unusually long lived. Correct tension is easily maintained. Adjustments are seldom necessary.

Put Texrope Drives on the machines that give you the most trouble in your plant. Let the superior performance of Texrope prove its economy to you.

Over 75,000 Texrope Drives Giving Satisfactory Service

The Texrope Drive, originated by Allis-Chalmers, has proven to be "The Perfect Transmission." Insist on getting Texrope. Today over 75,000 Texrope Drives are in satisfactory service, in practically every industry, transmitting power up to 2,000 H. P. per single drive.

Texrope belts and grooved sheaves up to 100 H. P. and in ratios up to 7:1 are carried in stock at points that permit prompt shipment to all parts of the country. Let us show you how Texrope Drives will end your transmission troubles and help you cut costs. Write for a copy of Bulletin 1228-K.

ALLIS-CHALMERS MANUFACTURING COMPANY, (*Texrope Division*)
Specialists in Power Machinery Since 1846 Milwaukee, Wisconsin

ALLIS-CHALMERS
TEXROPE DRIVES

THE PERFECT TRANSMISSION — ALLIS-CHALMERS TEXROPE DRIVE — FOR EVERY PURPOSE

INDUSTRIAL ENGINEERING

Founded in 1882 as Electrical Review. Consolidated with it—Western Electrical and Industry Illustrated.

Maintenance Engineering in Plants, Mills, and Factories, as Applied to Electrical and Mechanical Equipment and Buildings

L. C. MORROW, *Editor*

Volume 88, Number 6

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July *Industrial Engineering* is to be a "Modernization" issue. Such a theme implies a sermon, but the editors will not preach.

For the most part they will let pictures tell their story—pictures that show installations of modern equipment in many plants making products of wide variety.

There will be articles by several plant men telling of the whys and hows of important equipment changes in their plants—again no preaching.

Industrial modernization is carried on for only one purpose—to provide means for reducing costs or making more profit. Selfish objectives? By all means—let's have it so.

And that you may see how these selfish objectives actually are being carried out—that's our objective.

WILBUR A. BECK
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G. A. VAN BRUNT
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Consulting Transmission Editor

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Business Manager
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LINK-BELT

A Sturdy Positive Drive

HERRINGBONE SPEED REDUCER

This compact, powerful speed reducer is an important unit in the complete line of Link-Belt positive drives. Its Sykes-tooth herringbone gears, without center gap, are the strongest gears made.

It is fitted with oversize, anti-friction bearings. Capable of high speed ratios, up to 300 to 1, it permits the use of the economical, high-speed motor. Let us send you more detailed information.

INDUSTRIAL ENGINEERING

Maintenance Engineering in Plants, Mills, and Factories, as Applied to Electrical and Mechanical Equipment and Buildings

A McGraw-Hill Publication, founded 1882

Volume 88 **CHICAGO, JUNE, 1930** *Number 6*

The mechanical repair shop.

A permanent stock of more than 12,000 spare parts, of $1,250,000 value, is just part of the story of . . . . . .

INLAND STEEL

Mechanical Maintenance

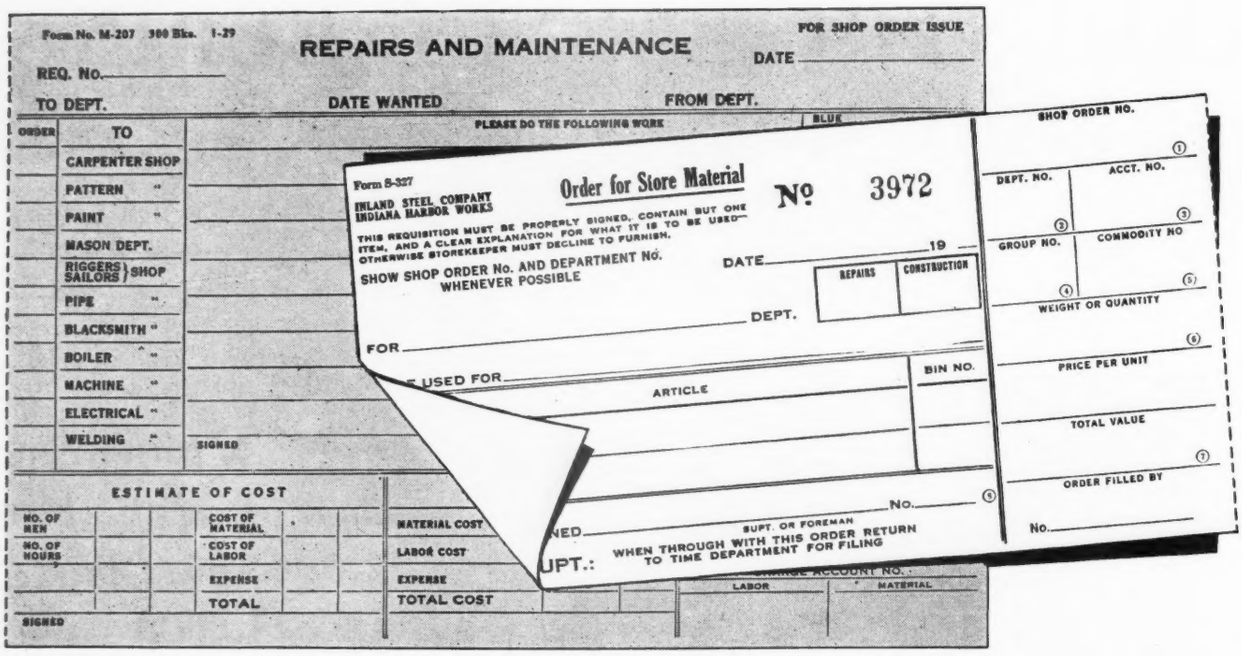
By BENJ. S. BURRELL

General Master Mechanic
Inland Steel Company
Indiana Harbor, Ind.

SOME idea may be had of the magnitude of mechanical maintenance activities at the Inland Steel Company, Indiana Harbor, Ind., when it is known that over 12,000 different items, representing finished spare mechanical parts and valued at over $1,250,000, are carried in all departments excluding stores, ready for immediate use.

Outside of the steel and perhaps the automotive field, few industries can show the absolute need for such resources to tide them over the unexpected emergency, regardless of its character. It is realized that tremendous capital is tied up in carrying this volume of material, but there is justification in doing so, particularly when an instance cannot be recalled during the past 5 years where any part of the plant was delayed for the need of a spare part. Be that as it may, spare parts represent but one factor in the mechanical maintenance scheme at this plant. Of greater importance is the personnel, its training; the co-operation exchanged between mill departments, in addition to rewards from the management by means of an incentive system, all of which will be discussed later in this article.

Inland Steel is representative of many other steel plants, varying somewhat in capacity and products, however. It is made up of three plants—Indiana Harbor works, Chicago Heights plant, and the Mil-



A mechanical department order to any of the sub-divisions requesting work to be done on mill equipment sent to the shop for necessary repairs.

Stores material for any job that has been assigned a shop order number will be issued on presentation of this form when properly signed.

waukee plant—the output of which in 1929 approximated 1,750,000 tons of ingots. Recent additions raise this figure considerably.

At present four blast furnaces are available for the manufacture of pig iron. Coal and ore are shipped to the plant by boat and unloaded by means of seven bridges. A considerable amount of belt conveyors is used in handling this material. There are 214 ovens used in producing coke, a small part of which is sold for domestic use. By-product recovery is strongly emphasized at this plant.

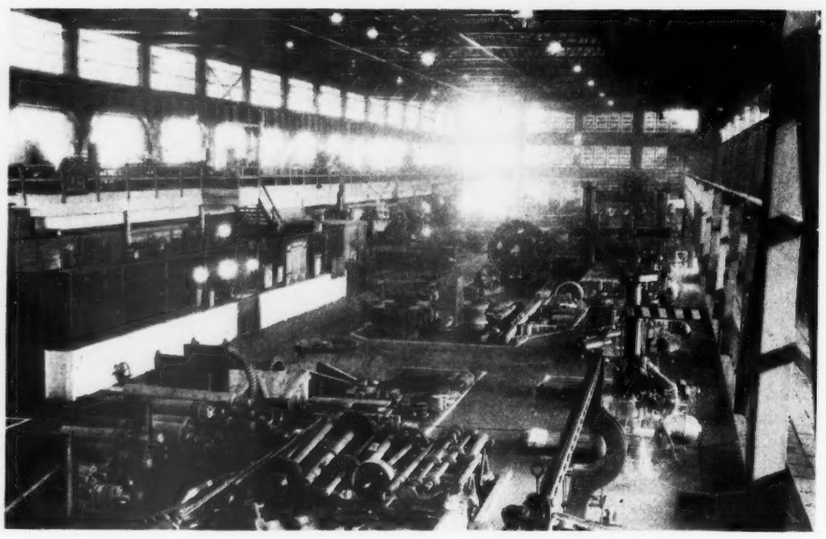
There are 27 open-hearth furnaces; 12 in No. 1 plant, and 15 in No. 2 plant, served with the required complement of charging and ladle cranes.

Drives for the 40-in. blooming mill, 35-in., and 28-in. mills are 15,000, 7,500 and 7,500 hp. respectively. The 24-in. billet mill is driven by a 6,250-hp. motor. The 14-in. merchant mill which is driven by a 6,000-hp. motor is served by six 15-ton cranes. A 10-in. merchant mill utilizing four cranes is under construction. The 36-in. blooming mill is driven by a 7,000-hp. motor, and the 24-in. billet mill parallel to it is driven by a 3,000-hp. motor. Other departments consist of a 19-in. sheet bar mill, a 24-in. reversing bar mill, an 8-, and an 11-in. Morgan mill, a 100-in. plate mill, an 18-stand sheet mill, and a bolt and rivet mill. In all there are 160 overhead cranes of varying capacities serving these mills. As all mills are motor driven, power is furnished at 2,400 volts, 25 cycles by the plant in handling 28,000-kw. average, and 40,000-kw. maximum peak loads.

From the foregoing outline one can obtain a picture of the diversified equipment in use, which is serviced by the mechanical maintenance group.

Steel plants in addition to their primary purpose require adequate repair facilities which, in this case, are concentrated in a group of mechanical repair shops. Here are found men and equipment capable of taking care of any mechanical repair work needed by the plant and within the capacity of the machines. The layout is for maximum efficiency in expediting the return of production equipment to service, and the building of certain new equipment within our range.

By referring to a plant layout it will be seen that the main mechanical



This view is toward the opposite end of the shop previously shown. All clerical work for the shop proper is handled in the inclosure to the left. A variety of equipment in for repairs is seen in the foreground.

repair shop is located about in the center of the building group in plant No. 1, which location has an advantage from the standpoint of materials handling costs. The building measures 86x620 ft., 200 ft. of which is allotted for use as a boiler and structural repair shop. The entire floor is served by two cranes; one of 40-ton capacity, the other 10-ton. A gallery 18 ft. wide and 400 ft. long extends along one side, which is equipped for small tool work. Under a lean-to on the opposite side is another gallery containing a belt shop, wash and locker rooms, tool room, and the mechanical departments' offices.

All equipment is direct motor driven. It consists of the following: 19 engine lathes, 4 planers, 6 shapers, 3 milling machines, three 6-ft. drill presses, 4 vertical drill presses, 2 slotters, 3 gear cutters, 3 horizontal boring mills, 3 turret lathes, 3 screw machines, 1 key seater, 3 saws, 3 bolt cutters, 1 drill grinder, one 600-ton wheel press, one 48-in. surface grinder, 1 universal tool grinder, 1 shaft straightening machine and 5 double abrasive wheel stands.

In addition to the overhead cranes, jib cranes equipped with chain hoists are used to handle the light castings and forgings to and from the various machines, thus relieving the larger cranes of considerable work.

At the side of the machine shop a welding shop has been established which is equipped to do electric, gas, or thermit welding. It is operated in connection with the machine shop; the reason being that most of the machinery to be repaired or reclaimed by means of welding passes in and out of this shop.

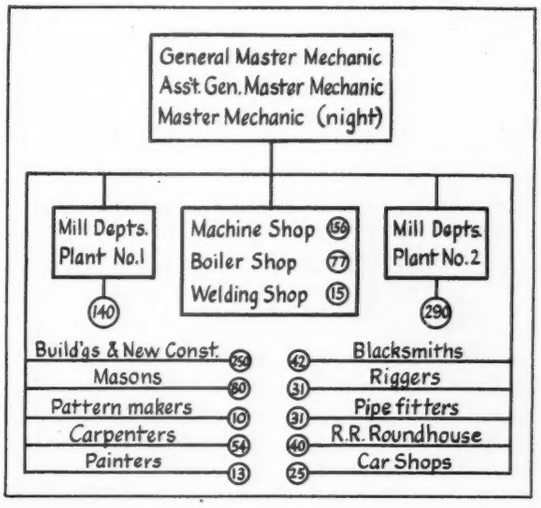
Other departments in the shops system equipped to carry on repair activities are as indicated on the organization outline. In the round house which is arranged with 13 stalls, served by a 70-ft. turntable, one finds certain small auxiliary tools for minor repair work, however, the major work for the 30 locomotives and 13 locomotive cranes in the yards materials handling system is handled by the main machine shop. The railroad equipment in this system ranges in size from 30-ton narrow-gage to 85-ton standard-gage locomotives. Locomotive cranes range in capacity from 5 to 50 tons. The car shop is fitted out to take care of repairs and the rebuilding of all car equipment consisting of 421 cars of various capacities. All large plate and structural work necessary for this work is furnished to the car shop by the boiler or structural shops.

Supervision over the entire foregoing equipment is maintained by the general master mechanic. He is assisted by an assistant general master mechanic, who is detailed to coordinate the activities of the various shops and mill departments. In addition, there is a master mechanic in charge at night.

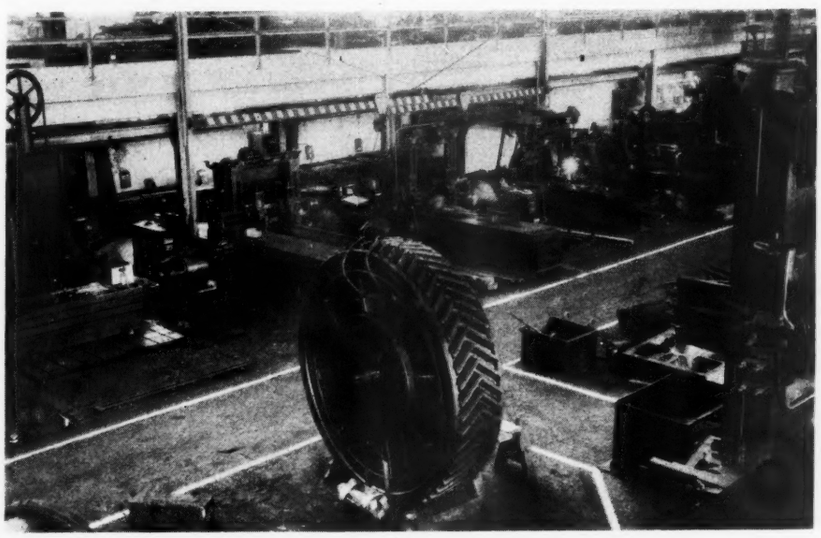
An outline of the entire mechanical organization is included to show its ramifications which coincide closely with other plant engineering organizations engaged in service-to-production work. Every sub-division functions as a unit, although the members of the mill groups are just as responsible to the superintendents in the various mills as other production workers coming under their direct supervision. In this case the exception is with crane operators, who are primarily production men. The mechanical department maintains all cranes as far as the motor shaft. The electrical department is responsible up to and including the attachment on the motor shaft, be it pulley, coupling or gear.

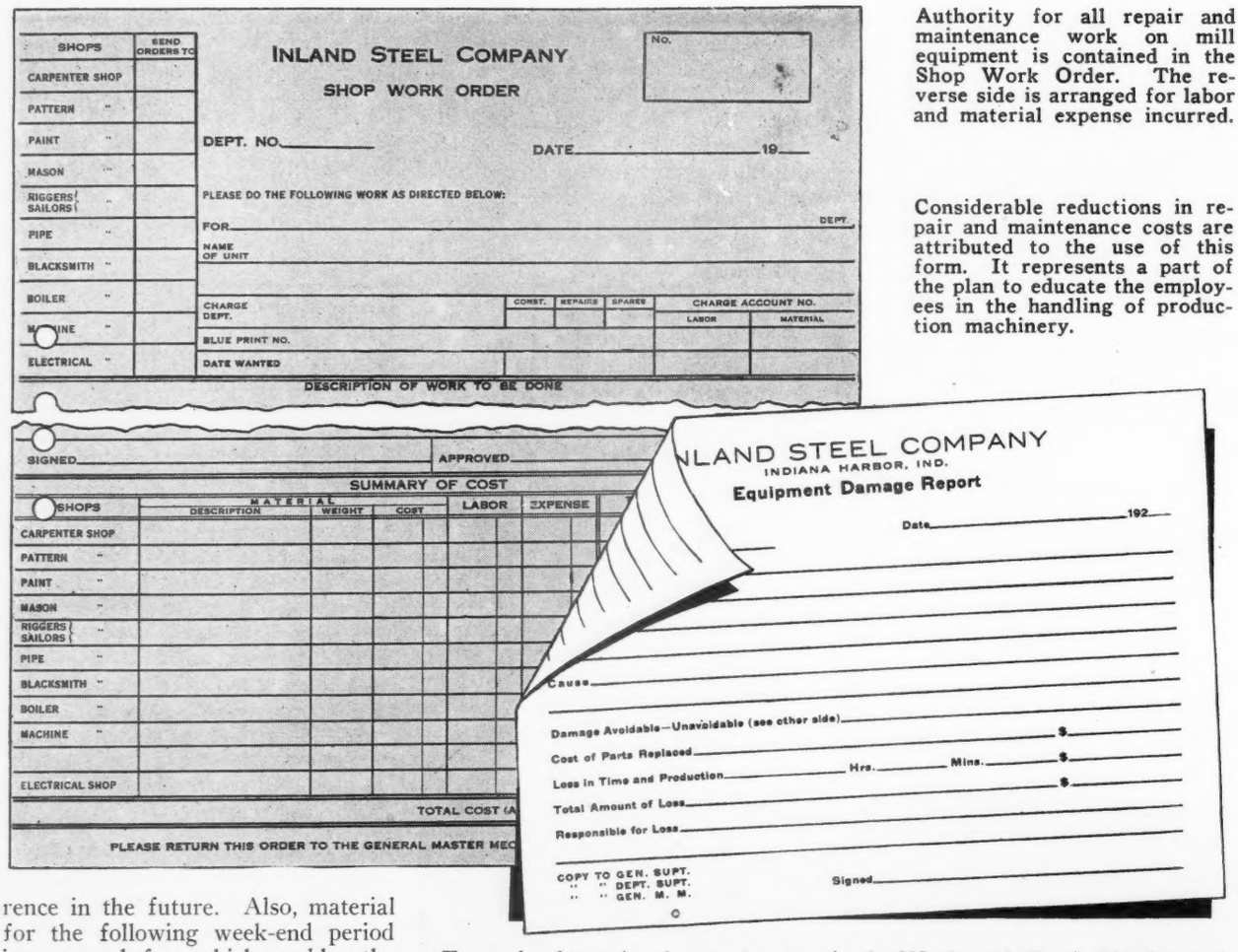
As a means of keeping in close touch with such a large force weekly meetings are scheduled, which are held every Monday morning in the general master mechanic's office. These meetings are conducted by the general master mechanic and attended by his assistant and all departmental and master mechanics and machine shop foreman. Their purpose is to discuss week-end activities such as certain repair work accomplished over the preceding week-end and to formulate plans for the following week-end period when certain parts of the plant will be shut down. If difficulties have been experienced during the previous week-end period mention is made and steps are taken to prevent their re-occur-

Organization chart of the mechanical maintenance groups. The number of normal full-time employees in each department is indicated in the circle.



A close-up of a gear of noble size. It is from a 40-in. blooming mill hot shear. This unit is a spare and repairs are being rushed so as to make it available in case of an emergency.





INLAND STEEL COMPANY

SHOP WORK ORDER

NO.

DEPT. NO._____ DATE_____ 19__

PLEASE DO THE FOLLOWING WORK AS DIRECTED BELOW:

FOR_____ DEPT.

NAME OF UNIT

SHOPS	SEND ORDERS TO
CARPENTER SHOP	
PATTERN "	
PAINT "	
MASON "	
RIGGERS SAILORS "	
PIPE "	
BLACKSMITH "	
BOILER "	
MACHINE "	
ELECTRICAL "	

CHARGE DEPT. | CONST. | REPAIRS | SPARES | CHARGE ACCOUNT NO. LABOR | MATERIAL

BLUE PRINT NO.

DATE WANTED

DESCRIPTION OF WORK TO BE DONE

SIGNED_____ APPROVED_____

SUMMARY OF COST

SHOPS	MATERIAL DESCRIPTION	WEIGHT	COST	LABOR	EXPENSE
CARPENTER SHOP					
PATTERN "					
PAINT "					
MASON "					
RIGGERS SAILORS "					
PIPE "					
BLACKSMITH "					
BOILER "					
MACHINE "					
ELECTRICAL SHOP					

TOTAL COST (A

PLEASE RETURN THIS ORDER TO THE GENERAL MASTER MEC

NLAND STEEL COMPANY

INDIANA HARBOR, IND.

Equipment Damage Report

Date_____ 192__

Cause_____

Damage Avoidable—Unavoidable (see other side)_____ $_____

Cost of Parts Replaced_____ $_____

Loss in Time and Production_____ Hrs._____ Mins._____ $_____

Total Amount of Loss_____

Responsible for Loss_____

COPY TO GEN. SUPT.
" " DEPT. SUPT.
" " GEN. M. M.

Signed_____

Authority for all repair and maintenance work on mill equipment is contained in the Shop Work Order. The reverse side is arranged for labor and material expense incurred.

Considerable reductions in repair and maintenance costs are attributed to the use of this form. It represents a part of the plan to educate the employees in the handling of production machinery.

rence in the future. Also, material for the following week-end period is arranged for, which enables the shops to plan for the work ahead.

At the same time ways and means are discussed to bring about reductions in the cost of repair and maintenance activities, as well as improving the methods of performance.

Departmental master mechanics in attendance at these meetings have the privilege of suggesting improvements that can be made. These suggestions are acted upon by the general master mechanic and his assistant in conjunction with the mill superintendent of the department in which the changes are contemplated.

Aside from their mechanical duties these departmental master mechanics are responsible for buildings and structures within their department. Repairs to such equipment is their responsibility insofar as they are able to function. If the repair is of a minor nature the mill mechanic, upon approval of the mill superintendent, proceeds with the work. Other building repair work calls for comment by the general master mechanic and mill superintendent, who decide whether it is necessary for the building inspector to determine the extent and make needed recommendations.

From the foregoing it may be appreciated that very close co-operation between the production and service-to-production departments is absolutely necessary if the maximum of results is to be obtained at a minimum cost, which is the basis of all repair and maintenance work at this plant. Putting the mechanical department on a business plane necessitated, in addition to co-operation from all mill departments, foremen educated to the level of their work so that the acme of efficiency could be obtained with the quality of men available. Compared to 1921 the labor turnover in the department is the lowest in the history of the plant, which is a true index of the methods employed in handling men and performing the required tasks.

In 1922 an intensive effort was made to interest the mechanics in our employ in the economical procedure of their work, the first step being to point out the advantages of constant employment. Precision and economy was then emphasized as a means of teaching them that work well done was twice done—repeating an old axiom. Excellent results were being obtained in enlisting the men in the Workmen's Profit Sharing and Pension Fund Plan that was instituted in 1919, which enabled an employee to share company earnings through a system of saving a fixed percentage of his earnings.

From the success in this direction, that is, reduced labor turnover, and good attendance, the plant mechanical executives were assured that the time could now be well spent in establishing a sound system of education as a means of reducing repair and maintenance costs. Coupled with an incentive system which was instituted in 1924 for all mechanical maintenance men, the plans laid out began to bear fruit. During the 6-yr. period to date we have reduced our repair and maintenance costs per ton approximately one-third while the percentage of rolled products shipped has increased 47 per cent. Each year shows a marked reduction in these costs, which is wholly attributed to the systems of education and incentives applied. To accomplish this reduction many changes in machine design as well as methods of procedure were necessary.

As applied to the mechanical maintenance personnel the incentive

wage-payment system functions in practically the same manner in all mill departments of this plant.

In general, the procedure in servicing the various plants or mill departments is definitely established. In the case of a breakdown the general master mechanic is at once notified by his departmental master mechanic. Repairs are rushed by that mill department in trouble to minimize the delay, and if necessary help is obtained from the shops system to expedite the return of the equipment to service.

Every job is covered by a formal Shop Order inasmuch as verbal orders are not accepted. All charges for labor and material must be entered on the Shop Order, likewise this shop order number must go on Stores Requisitions for material necessary to complete the repairs.

After a job is completed the general master mechanic's office sends out to the mill department in which the breakdown occurred a bill covering the labor and material cost of doing the work. In this manner everyone in the department (maintenance personnel included) becomes familiar with the cost of the various items entering into the work. Also, it serves to keep them aware of the fact that greater precaution must be used if these costs are to be reduced.

Form S 78 A 25M Sale 7-30

INLAND STEEL COMPANY
INDIANA HARBOR WORKS

DEPARTMENT REQUISITION No.
STORE ROOM REQUISITION No.
PURCHASING DEPT. ORDER No.

Date_____19___

Mr._____Vice-President

Please order the following for_____Department

Charge_____ Use Separate Requisition for each commodity.

QUANTITY	DESCRIPTION	ON HAND	USED PAST 3 MONTHS	PRICE AND DELIVERY

Ordered from_____

Date Received at Store Room_____ Remarks:_____

Date Approved by Gen'l M. M._____

Date Approved by Chief Eng'r_____

Date Approved by Asst. Gen'l Supt._____

Date Approved by Gen'l Supt._____

Date Received by Pur. Dept._____

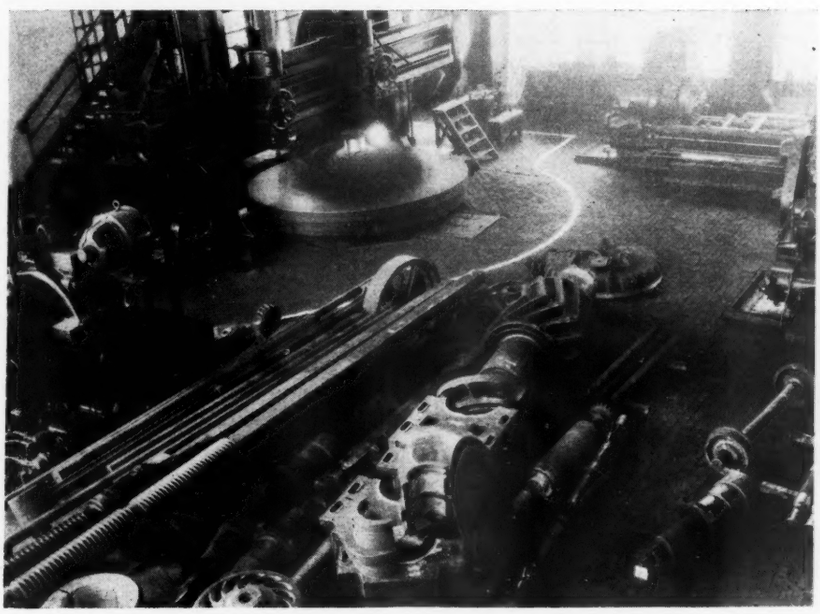
APPROVED:

_____ Superintendent

_____ Assistant Treasurer

_____ Storekeeper

Material not ordinarily carried in the stores department is purchased direct by any department if requisitioned on this form and, of course, if approved.



Just a few of the items sent to the repair shop for overhauling. In this and other views note the white lines on the floor which outline traffic lanes that must be kept clear at all times.

After a breakdown occurs and the department is in operation the assistant general master mechanic makes a thorough investigation of the cause of the damage. He fills out an Equipment Damage Report which includes a description of the equipment damaged, an unbiased reason for the breakdown, loss of money owing to the repair or replacement of the machinery parts, total loss of equipment, and loss of time to the department in money. In this report, he charges the employee responsible for the breakdown, and on the reverse side adds any information that will be of value in preventing a similar accident in the future. A copy of this report is handed to the party, who is charged with neglect. A copy is sent to the general superintendent, whereas another copy goes to the mill superintendent concerned. The original is retained by the general master mechanic.

This report is made out without fear or favor to anyone. The purpose is not to bring about the discharge of the worker, but to educate him to the cost of a breakdown and all incidental losses incurred. The additional value derived from its use is the building up of a permanent file or list which is referred to when promotions are to be made. Repeated breakdowns appear against a man's record, therefore, it is to his advantage to prevent an accident that would bring his name before the management.

All labor and material cost data pertaining to mechanical shops and mill repair and maintenance are furnished complete to the mechanical department by the works auditing department on the 1st of each month. This data is then forwarded to the departmental foreman and master mechanics by the 10th of the month, complete for their departments. With this information these men are able to study their expenses and devise ways and means of reducing them. The data is also submitted in

graph form to departmental master mechanics on all important divisions of his department, comparing month-to-month and year-to-year costs. It carries complete detailed costs of all commodities such as oils, greases and so on used by his department.

All spare machinery parts for the various departments are purchased outright at the time of manufacture and are carried as finished spares in the respective departments where they will be used. Under the chief storekeeper there is a clerk, whose duty it is to visit the various departments daily in order to keep the record of spare equipment up-to-date. All spare parts thus carried in the mill departments are (numbered and tagged) charged out as spares until used when the tag is removed and carried in a department file until the spare is replaced, at which time the tag is attached and the record adjusted accordingly. This clerk also maintains in his office at the main stores department a complete record of all finished spares carried by all departments.

At the end of each year a complete inventory is taken and from it data is tabulated to show the increase or decrease over previous years. A constant effort is being maintained to hold its value to a minimum and at the same time give complete assurance of constant plant operation. Of the material passing through the stores department practically 75 per cent is used by the mechanical department.

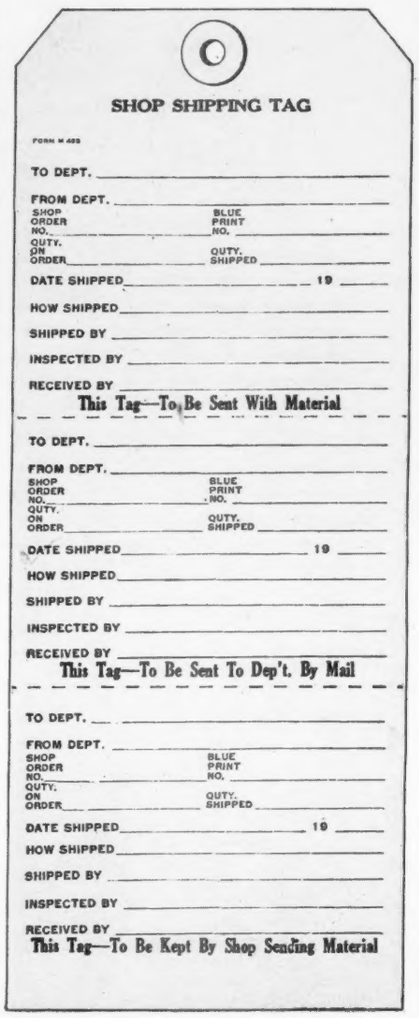
In other departments the procedure followed in satisfying the need for maintenance is based on plant experience. Building and structural maintenance is dependent upon the results of inspections made by a building inspector. His reports are submitted to the various mill superintendents and general master mechanic, who decides what work shall be done during the ensuing year.

On the docks where 21 ore-bridge operators are employed, general overhauling and painting are postponed until the winter months. Ordinarily these operators maintain their own equipment, but for the closed season employment becomes the privilege of the operator having the least number of delays during the open season. Last year 95 per cent of the force were eligible for winter work.

A few of the outstanding reasons for our success in lowering year-by-year repair and maintenance costs are as follows:

1. Education of all mechanical men in the plant as to the monetary value of the articles they are handling including all cost data pertaining to breakdowns.

2. Substitution throughout the plant of heat-treated equipment parts such as alloy steels, hardened tool-steel machinery parts, manganese steel parts and so on, for materials less suited for steel-plant use.


SHOP SHIPPING TAG

FORM M 405

TO DEPT. _____

FROM DEPT. _____

SHOP ORDER NO. _____ BLUE PRINT NO. _____

QUTY. ON ORDER _____ QUTY. SHIPPED _____

DATE SHIPPED _____ 19 ____

HOW SHIPPED _____

SHIPPED BY _____

INSPECTED BY _____

RECEIVED BY _____

This Tag—To Be Sent With Material

TO DEPT. _____

FROM DEPT. _____

SHOP ORDER NO. _____ BLUE PRINT NO. _____

QUTY. ON ORDER _____ QUTY. SHIPPED _____

DATE SHIPPED _____ 19 ____

HOW SHIPPED _____

SHIPPED BY _____

INSPECTED BY _____

RECEIVED BY _____

This Tag—To Be Sent To Dep't. By Mail

TO DEPT. _____

FROM DEPT. _____

SHOP ORDER NO. _____ BLUE PRINT NO. _____

QUTY. ON ORDER _____ QUTY. SHIPPED _____

DATE SHIPPED _____ 19 ____

HOW SHIPPED _____

SHIPPED BY _____

INSPECTED BY _____

RECEIVED BY _____

This Tag—To Be Kept By Shop Sending Material

Facsimile of shipping tags in color. Blue tags are used by mill departments in sending parts to the shop for repairs. The shop uses salmon-colored tags in returning the finished parts to the mill departments. A shop order number and other data identifies the part. Each tag section bears identical information.

3. Modernizing the system of lubrication. By the intelligent application of greases and oils of the proper grades gearing and other elements in the line of mechanical power transmission are giving upwards of double the life formerly obtained. For example, where equipment was forwarded to the machine shop for repairs after an average of 8 months' operation, the period of service now averages 18 months. Good lubrication has also made reductions in the amount of power necessary to manufacture the products as well as giving longer life to bearings. Sheet mill roll train lubrication is considered the greatest lubrication expense in any plant operating standard type mills, yet the cost for brass bearings, also the cost of lubricating them per net ton of product is $0.085 in each case. In its entirety the plant is lubricated, however, at an approximate cost of 6 cents per ton of rolled products shipped.

In the past four years there has been a reduction in the replacement cost of 25 per cent for brass bearings and 23½ per cent for babbitt bearings used in the plant, and at the same time lubrication has been accomplished for 40.9 per cent less money.

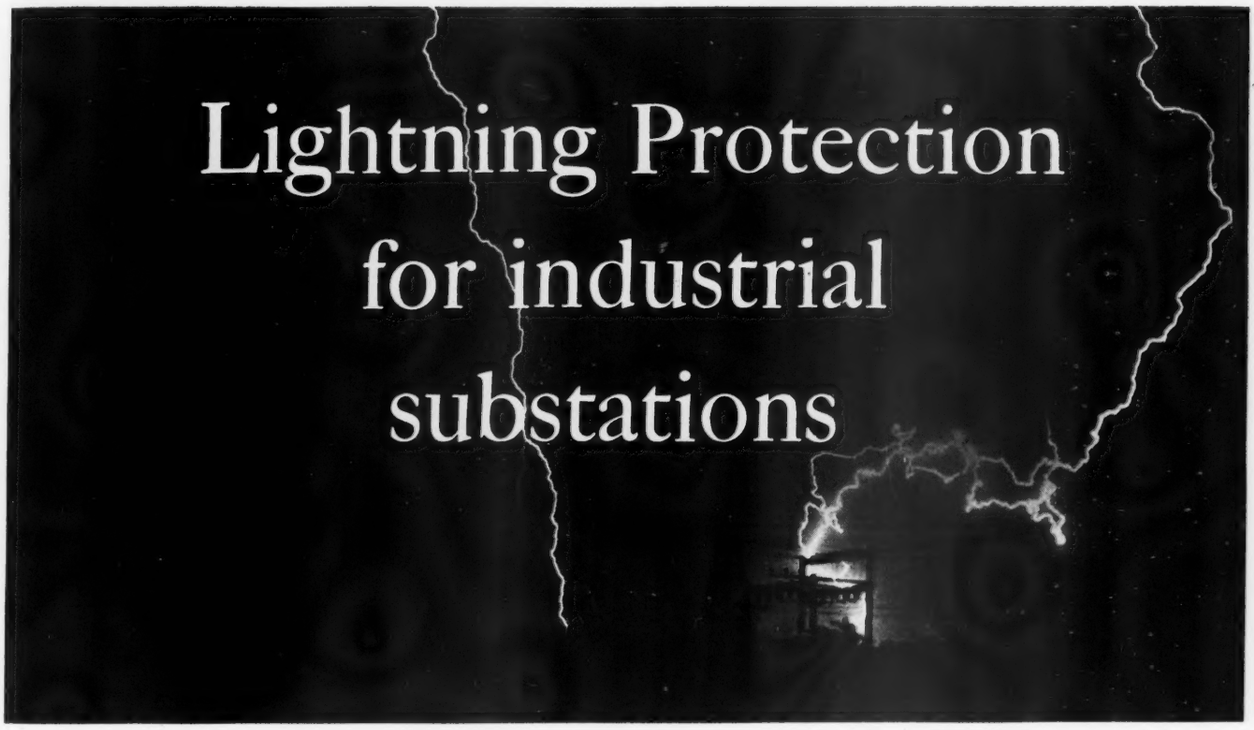
4. Care on the part of machinery operators throughout the plant. This betterment has been largely brought about through the use of the Equipment Damage Report which is continually bringing to the attention of the men the value of the equipment concerned, the cost of damages through breakdowns, and the loss in production occasioned by the delay. This report is considered to be responsible for a reduction of repair and maintenance cost to the amount of approximately $100,000 each year.

5. The installation of the incentive system throughout the entire mechanical forces, which provides for a bonus of 10 per cent on savings. This system has also been instrumental in lowering the labor turnover to a minimum, and in making all employees interested in the economical fulfillment of their duties. It has done its part in effecting a saving of 25 per cent in repair and maintenance cost per ton produced since its adoption. It is fair to assume that the incentive system is responsible for approximately 50 per cent of this saving.

Percentage savings in repair and maintenance costs per ton of rolled product shipped in 1924 compared to figures for 1929 are as follows:

Labor	**49.5 per cent**
Material	**44.2 per cent**
Increase in rolled products shipped	**47.0 per cent**

6. All mechanical shop work being billed against the receiver upon completion of the work, thereby acquainting the mill forces as to the value of all machinery parts including costs of shop work.



Lightning Protection for industrial substations

By H. M. TOWNE

Central Station Department
General Electric Company
Pittsfield, Mass.

LIGHTNING potentials on electric circuits probably occur chiefly by electrostatic induction attending the discharge of a cloud in the vicinity. Direct strokes or side flashes terminating on the electric circuit are unquestionably most destructive, frequently resulting in shattered crossarms, splintered poles, broken insulators, or fused conductors. However, practical observations and field studies indicate that these effects from direct strokes are in the minority, particularly with the low- and medium-voltage systems which more commonly serve industrial substations. On these systems dangerous potentials are manifested by line or station flashovers, which may occur frequently without a direct stroke on the circuits.

With very high voltage and necessarily highly-insulated transmission systems, induced potentials that would endanger the insulation will occur less frequently, but direct strokes may occur more frequently because the towers are of steel, are high and fairly well grounded, and the circuit presents greater exposure. In general, the induced potentials from lightning become less hazardous to system insulation as the system voltage rating increases. For systems of 66 kv. and below, the lightning protection problem involves essentially the induced effect.

Lightning impulses on electric circuits may be either positive or negative in polarity. By electrostatic induction the lightning voltage on the line will be of opposite sign to the charge on the cloud. Direct strokes on the line will cause a voltage of the same sign as the discharging cloud. Lightning impulses are generally unidirectional, although they may culminate in oscillations or reversals of polarity by line flashovers or reflections. The impulses rise from zero to crest voltage in a few microseconds (millionths of a second) and decay at a slower rate to zero voltage. The total duration of the impulse may be from 20 to 100 microseconds, or more.

Lightning impulses may be superimposed on any point of the 60-cycle or system voltage wave. The lightning voltages will generally occur simultaneously on all conductors of a multi-conductor circuit, with the highest voltage appearing on the highest or most elevated conductor. The impulse exists for only a very brief part of a half cycle of the system voltage frequency. This is apparent when we consider that a half cycle of a 60-cycle system voltage represents about 8,000 microseconds.

Lightning impulses travel along the electric circuit at the velocity of light, roughly 1,000 ft. per microsecond. In cables, however, the velocity of propagation is about half of that on an overhead line, the exact reduction in velocity depending on the dielectric properties of the cable.

These impulses or traveling waves attenuate, or decay, in magnitude in their movement along the circuit, and it is possible to determine the distance that surges can travel and still be dangerous to connected apparatus. Attenuation is largely due to corona loss, although the polarity and length of the wave, and the presence of parallel conductors or overhead ground wires have an influence. Although the attenuation varies for different circuits, a fair approximation for practical considerations is that a 1,000-kv. wave will attenuate to 500 kv. in about 6 miles, and a 500-kv. wave will attenuate to 250 kv. in about 12 miles.

The design of the transmission line and its insulation greatly influence the lightning protection problem. Line conductors should be kept as close to the ground as possible. Increasing the line insulation will tend to reduce the number of lightning flashovers on the line, but will permit higher voltages to be propagated along the line to terminal apparatus. The latter effect, however, can be avoided by co-ordinating the line in-

sulation for a half mile, or a few spans, out from the station.

This co-ordination program involves keeping the line-to-ground flashover value of the line insulation adjacent to the station equal to or slightly less than that of the station insulation, thus permitting incoming surges to flash over a short distance away, rather than at or within the station. The remainder of the line insulation may then safely be made as high as desired, to reduce flashovers on the major part of the line to a minimum.

Lightning has been said to be the greatest single factor limiting the continuity of electric service.

Present-day manufacturing processes require a dependable source of power.

The answer?—proper protection.

An overhead ground wire may be employed to reduce the amplitude of the induced voltage on the line from 30 to 50 per cent, which may in turn reduce the number of line flashovers by an even higher percentage.

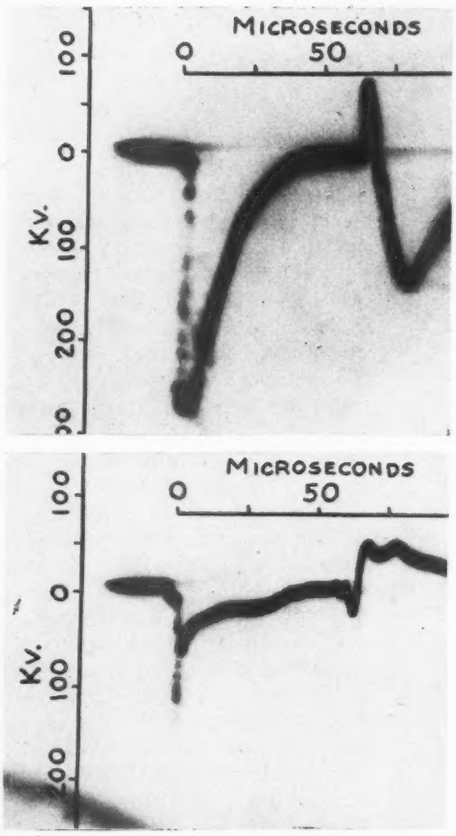
The lightning flashover voltage is fairly definite for lines with steel towers or grounded hardware, but is less definite for wood poles and crossarms in series with the line insulators. Wood greatly increases the lightning flashover value of a line; this increase is about the same for dry, wet, creosoted, or untreated poles or crossarms. The lightning flashover voltage for wood is about 180 kv. per foot. For a wood pole line the lightning flashover is generally very high, frequently exceeding that of circuits of much higher rating on steel towers. The weak point of the wood pole line is where guy wires are located close to the crossarms, and where metal crossarm straps or braces shunt out most of the wood between line and ground. Use of wood crossarm braces and wood strain insulators in the guys will aid greatly in increasing the flashover strength of the line. Keeping the guy wires well below the metal crossarm braces also helps to utilize the flashover strength of the wood pole.

The use of overhead ground wires on wood pole lines may frequently be disadvantageous. For example, a wood construction line may have a flashover strength involving the insulators plus 10 or 20 ft. of wood from line to ground. The addition of a ground wire may reduce the flashover strength to that of the insulators plus perhaps only 2 or 3 ft. of wood crossarms. Then, although the overhead ground wire may cut the induced lightning potentials to 50 per cent, the flashover strength of the line to ground may have been reduced to even 25 per cent, so that the net result might be to make the line more susceptible to lightning flashovers.

The overhead ground wire is, however, always advantageous on steel tower lines, or lines that have grounded steel crossarms or insulator hardware.

With wood pole lines the coordination of the line insulation adjacent to the station will generally involve grounding the insulator pins or hardware for a half-mile out from the station on each pole. This insures that the flashover value of the line immediately adjacent to the station is no higher than the station insulators or apparatus.

The lightning flashover voltage of insulators or insulation in general depends on the steepness of the front of the wave and the length of the body or tail of the wave. On the front or rising part of the wave, impulses with wave fronts longer than 20 microseconds may cause flashover at only 10 or 20 per cent above the crest value of the 60-cycle dry flashover. For wave fronts less than one microsecond the flashover voltage may be two or three times the 60-cycle crest value. Flashovers may occur on the body or tail of the wave at voltage values lower than required to flash over on the front of the wave.



Showing the protective action of an oxide-film arrester. The voltage in the upper oscillogram was measured without the arrester; lower with the arrest in circuit. The 0.5-microsecond impulse was applied to the line about six miles from the station.

The impulse flashover of insulators is not affected by rain; that is, the wet flashover is substantially the same as the dry flashover. Dust and dirt accumulations on insulators will not appreciably reduce the lightning flashover, particularly at the steeper wave fronts. For the slower wave fronts a reduction in flashover will be noted. For 60 cycles, rain reduces the flashover, and rain together with dust or dirt causes a marked reduction in flashover.

Ordinary pin-type insulators have a polarity effect which is probably present in the flashover of any insulation where the voltage is applied between dissimilar electrodes. With pin insulators a positive voltage applied to the cap will cause flashover at a value 20 to 30 per cent less than with the negative polarity applied to the cap. With string insulators, this polarity effect is absent, particularly with more than three or

four units or discs placed in series.

The insulation throughout the substation should be carefully chosen to secure reliability against flashovers. The substation insulation should be as reliable, or perhaps more so, than the transmission line insulation or the co-ordinated insulation on the line adjacent to the station. Likewise, apparatus within the station should have the recognized factor of safety so that the aggregate insulation strength throughout the substation can be considered normal for the particular system voltage rating in question.

Cables, either single conductor or three conductor, find frequent application in industrial installations. Short sections of cable—500 or 1,000 ft. in length between the station apparatus and exposed overhead lines—will not materially alter the lightning potentials that can reach the station from the exposed lines. The amount of change in a lightning wave passing through the cable will depend on the steepness of the wave front, the length of the body of the wave, the length of the cable, and the values of the surge impedance for the cable and the line.

With a steep front wave the cable will slope off the wave front, thus reducing the rate of rise of voltage reaching the station. This action is beneficial because the more sloping wave fronts are less harmful in producing unequal distribution of the transient voltages in apparatus. Many of the waves occurring in service have such relatively slow fronts that the cable will not materially alter the rate of voltage rise.

When the wave enters the cable from the transmission line the lower surge impedance of the cable reduces the initial transmitted wave through the cable to perhaps 20 per cent. If the length of the wave on the line was not greater than the length of the cable the voltage which could reach the station would be reduced to about 20 per cent. However, when the length of the wave is several times the length of the cable, a succession of voltage reflections within it will permit nearly the full voltage of the applied wave to be built up.

Lightning arresters of the line type should be installed directly at the junction of overhead lines and cables to protect the cable potheads and reduce the magnitude of the lightning impulses which pass through the cable. In addition, arresters should be used on the station bus to prevent those impulses which pass through the cable from approaching double value by reflection at apparatus terminals.

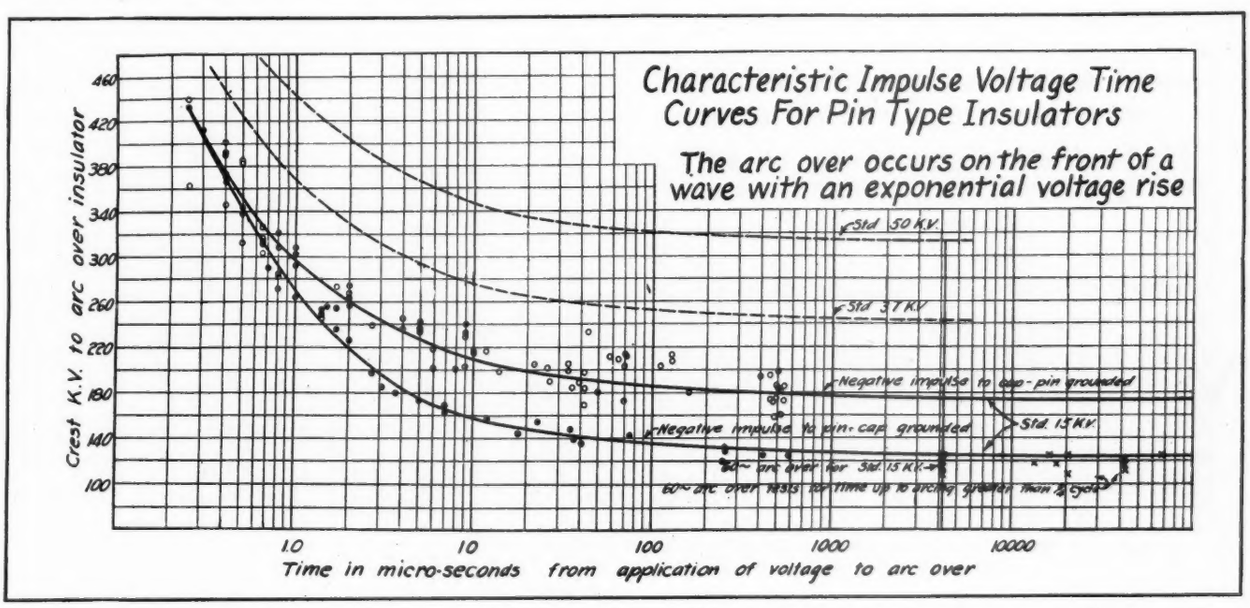
There is no reason to expect a difference in the severity of lightning voltages occurring on systems with grounded or nongrounded neutral. The magnitude of lightning potentials for either circuit depends upon the exposure of the line involved. However, line or station flashovers are more likely to result in short circuits and interruptions when they take place on the grounded neutral, system.

The solidly-grounded neutral system permits special arrester application, giving better protection at lower cost. The interpretation of "solidly grounded" in this consideration is that the neutral of all generating or power sources to the circuit shall be permanently and directly connected to grounds of very low resistance, with no intervening reactors, resistors, fuses, or switches. It is important that there be no condition of system switch operation that can result in supplying the arresters from an ungrounded neutral point of power feed, as failure of an arrester of grounded neutral design is likely to result.

If the neutral is solidly grounded, the special, grounded-neutral arrester design may be applied anywhere on the system, regardless of the length of the transmission line or the isolation of stations. Grounded-neutral arresters will, in general, limit the lightning potentials to about 80 per cent of the values obtained with the isolated or non-grounded neutral arresters.

The selection and application of arresters for either grounded or non-grounded-neutral systems should involve careful consideration of the maximum system voltage. The lightning arrester is fundamentally a voltage device and, when properly designed, operates independently of the transmitted current, power, and size or number of generators used. It is essential that the arrester, under any condition of operation, should not have a potential in excess of its rating applied to it.

Methods of protecting electric circuits and stationary and rotating apparatus will be discussed in a succeeding article, to appear in an early issue.



These curves show how insulator flashover voltage varies with the time of voltage application.

INDUSTRIAL ENGINEERING

L. C. MORROW, *Editor*

Vol. 88 JUNE, 1930 No. 6

On to Buffalo for the Iron and Sheel Show

AGAIN the Steel show, this year at Buffalo. Accepting the risk of being accused of repetition we assert that the iron and steel industry is a proving ground for many kinds of equipment. The automobile builder sets up his own proving ground of rough roads, speed roads, curves, bumps, holes. Then he runs his test cars on those roads, knowing that if they will deliver a plentiful mileage without failure they will do more than the average car buyer will ask of them.

Equipment manufacturers find a ready-made proving ground in the steel plants. For the most part they are showing at Buffalo equipment that has taken the proof test so afforded, or that has been developed to meet such a test. Men from the steel mills will dominate the attendance, electrical men in particular, since the exposition is under the auspices of the Association of Iron and Steel Electrical Engineers. But mechanical power transmission equipment can't be divorced from electrical equipment. What use a motor without gears, belts, speed reducers, chains, or some other similar device to transmit the power to the equipment to be operated? Which means, specifically, that mechanical power transmission equipment, as well as motors, controls, and related electrical equipment will be shown. Anyone facing problems involved in transmitting power under severe service conditions will do himself a good turn by visiting the show.

Industrial Engineering will have a booth, as heretofore. The editors cordially invite you to visit them. The dates—June 16-20.

Selling the Idea of Modernization to 27,000 Industrial Plants

MUCH has been said about the benefits of modernizing industrial plants, and a good deal has been done about it. However, there has heretofore been no organized effort on the part of manufacturers of equipment, or others, to push the idea of industrial modernization in a big way. Now such a campaign has been instituted by the Electrical Association of New York.

This organization, whose membership is composed of electrical contractors, manufacturers, and representatives of the central station companies, has worked out a comprehensive plan whereby the advantages of complete electrical modernization can effectively be presented to the 27,000 industrial plants in the New York area.

It is not the purpose of the sponsors of this campaign to recommend the wholesale replacement of equipment that is modern enough to accomplish its purpose efficiently. Such a policy would be short-sighted and economically wasteful. Rather is it the purpose to point out, whenever possible, how costs can be reduced by the introduction of new methods or machines, or by the rearrangement, rehabilitation, or repair of existing equipment.

Granting that the backers of this modernization program are motivated largely by self-interest, the ideal behind it has much to commend it to the very serious consideration of every plant engineer and executive. Modernization is not a gold brick to be foisted upon a guileless purchaser. In its essence, it is a tried and proven means of getting more business and making more money.

The results of this campaign have yet to be seen, but there appears to be ample reason for believing that they will be gratifying. Certainly the campaign will be watched with interest, and it is to be hoped that the outcome will warrant its extension into other industrial centers.

Talk It Over with Your Friend the Fire Chief

EVERY industrial plant should have some firefighting equipment of its own and be ready when the time comes to put up an effective battle against the greatest enemy of industry—fire. How much equipment is needed, and how elaborate the organization behind it should be will depend on many factors, and must be decided for each plant individually.

However, no matter how large the plant fire department may be, it should not be forgotten that in the great majority of cases the local city fire department will be a valuable ally that can render great service in fighting a bad fire. In such emergencies a few extra hose lines, with trained men behind them, may make all of the difference between saving or losing property worth many thousands of dollars.

Every plant engineer may to his own great advantage make a friend of the local fire chief and work out the most effective plan of co-operation. In justice to himself and his men the city chief should be allowed to know the general layout of the buildings, what and where the serious fire hazards are, where explosives or highly

flammable materials are stored, details of the plant's protective equipment, and so on.

With this information, he will be able to render the most effective assistance, with the maximum safety to his men. Without it, he will be seriously handicapped in helping to fight an enemy that can in a few hours reduce the finest plant to a heap of smoking junk.

Make Them Quote Final Figures First

"QUOTE Final Figures First," says the National Machine Tool Builders' Association. In saying so it is talking to itself in an attempt to eradicate the practice of first and second and maybe third quotations, in lessening amounts, as the buyers say, "No, you're still out of line—you'll have to come down if you want the business."

What a mess it would be if it were common practice to buy clothes, shoes, hats, groceries, household furnishings, and the other ordinary commodities on the first-, second-, and third-price basis. There could be only one result: The third price would be what the first price should have been. The time lost and the nerves frayed would be beyond calculation and repair.

Each one of us has heard some story about the cagy buyer who always insisted upon a reduction from first quotation with the result that the seller adopted the practice of making his opening price high enough to allow one or more drops. Frequently he did not have to drop all the way, so the buyer paid more than he would have on a one-price basis.

Business just can't keep itself alive without profit, and the seller who cuts and cuts on price until he merely breaks even, or sells at a loss, is going out of business. What does the buyer care, you say? Quite a bit, quite a bit. Every manufacturer who goes out of business leaves behind him a trail of orphan equipment for which there are no service and no spare parts. Orphan autos and orphan radios tell that story.

"If they are foolish enough to keep on cutting prices that's up to them," we hear. And so it is, but it's a buyer problem too. If the buyer will say, "Gentlemen, quote final figures first—no other will be considered," he'll buy just as low in the long run, and he'll cut the cost of distribution as well as save his own time. Anyone who has played "shoot-the-moon" on both the one-bid basis and the auction basis knows what will happen.

Just no use kidding ourselves—we waste a lot of precious time in buying. And you can't get away from the fact that prices will work themselves out. Any bidder who gives an honest price based on "cost plus profit equals selling price" and finds the rest of the army consistently out of step with him is going to wake up to the fact that he's very, very good if he always gets the business and very, very bad if he always loses it. Then he's going to get busy with his plant and equipment and methods and before long he'll be a buyer himself, that is, a buyer of modern, cost-cutting equipment. It's an ill wind that does not pop somebody from the skillet into the fire.

The moral? Same thing we started out with: For the seller: "Quote final figures first." For the buyer, "Insist upon final figures first."

Keep the Maintenance and Production Departments Separate

ONE of the fallacies that not infrequently finds expression in actual trial revolves around the belief that maintenance of equipment can be handled effectively by the production department. Theoretically this view may be sound for, in truth, the production department suffers most when maintenance is neglected, but in practice it does not work out advantageously.

A well-known plant is now facing a very extensive and costly rehabilitation program because of its faith in that philosophy. Under the spur of a plan for increasing production, maintenance of all equipment was placed under the production department—and the inevitable happened. Production was stepped up in a gratifying way, but little attention was paid to maintenance.

Starting out with equipment that was in good condition, everything went along beautifully until the equipment began to give out under the stress of hard and continuous operation. Failure to make needed adjustments and minor replacements of parts led to more serious wear and bad breakdowns. What would have been minor maintenance jobs became major rebuilding jobs. A thorough inspection has shown that many thousands of dollars will be required to put the plant equipment in good condition.

As a rule to which there are probably few exceptions, a real maintenance job can be done only when it is made the direct responsibility of one individual who not only has the requisite technical knowledge, but has enough backbone and authority to insist that equipment be properly operated and cared for.

Next Month—July
Industrial Engineering's
Modernization Issue

Pictured on the Cover

IS the Ashland, Ky., plant of the American Rolling Mill Company, where the first continuous mill was built. A mile and a half of continuous operation is involved, beginning with the blast furnaces and ending in the finishing rooms and warehouses.

Total connected load is approximately 50,000 h.p. in motors which range from ¼ to 3,250-h.p. rating. Power is delivered at 33,000 volts, three-phase, 60 cycles. It is stepped down to 6,600 and 2,300 volts by three banks of 2,000-kva. transformers and a portion is again stepped down to 440 volts by three banks of 1,000-kva. transformers. Another portion is converted to 250 volts, direct-current, by five motor-generator sets with a total rating of 3,500 kilowatts.

The several mills and departments are served by a total of 43 traveling cranes.

Responsibility for electrical maintenance and repair work is vested in the superintendent of electrical maintenance. Next in line comes the electrical general foreman who bears responsibility for the maintenance of all electrical equipment. Direct contact with and supervision over all electrical maintenance activities are secured by one general foreman. In all there are six section and one shop foreman supervising electrical maintenance work. The total of the employees engaged in electrical maintenance work is more than 200. This number includes crane operators.

The mechanical maintenance force is so arranged that each division (blooming, bar, job, sheet, strip and galvanizing mills) has its own unit organization. There are more than 100 men, including inspectors, helpers, and oilers, in charge of five divisional foremen and one general foreman.

Both electrical and mechanical maintenance departments give 24-hr. service in eight hour shifts.

BOOKS

Applied Mechanics

By Frederic N. Weaver, Assistant Professor of Civil Engineering, Tufts College. Published by The Ronald Press Company, 15 East 26th St., New York, N. Y. Cloth, 317 pages, illustrated. Price, $3.25.

THE arrangement of the material in this work, which has been written primarily as a textbook for engineering students, is original, although it does not involve any radical changes from the conventional methods of presentation. In order to develop the principles of mechanics in an orderly and continuous manner, starting with Statics and Friction and proceeding through the subject of Motion, such topics as Center of Gravity and Moment of Inertia are treated in the appendix. Likewise, the various phases of Harmonic Motion have been treated under the heading of Periodic Motion, after Motion in general has been discussed. In preparing the text, it has been assumed that the reader has a knowledge of elementary calculus, but not of physics.

The general content of the work may be seen from the following chapter headings: Fundamental Concepts; Concurrent Coplanar Forces; Parallel Coplanar Forces; Coplanar Forces in General; Forces in Space; Machines; Friction; Rectilinear Motion; Kinematics of Curvilinear Motion and Rotation; Kinematics of Plane Motion; Periodic Motion; and so on.

A valuable feature for the reader who wishes to extend his knowledge of the subject, or review his earlier studies, is the large number of illustrative problems throughout the text. Answers are given to all these problems.

Universal Electric Motors

By A. F. Puchstein, Associate Professor of Electrical Engineering, and E. E. Kimberly, Assistant Professor of Electrical Engineering, Ohio State University, Columbus, Ohio. Published by The Engineering Experiment Station, Ohio State University. Paper, 72 pages, illustrated. Price 50 cents.

THE investigation reported in this bulletin, which is designated as Bulletin No. 53, was undertaken in an attempt to supply material not heretofore available, but necessary before a small universal motor can be selected, designed, or built in a rational manner. The results give data on the performance of motors ranging from 1/20-hp. and smaller to ¼-hp. rating, as determined on eleven sample motors submitted by three manufacturers. The data indicate what may be expected from such motors in the way of efficiency, power, factor, torque, current, volts on field and armature, reactance volts of commutation, transformer emf. induced in the short-circuited armature coils at rated current, speed at rated output, resistance drop, starting current, and so on.

From the measured results, approximate values were obtained for those constants needed by the designer, such as ampere-conductors per inch of periphery, gap flux density, copper-current density, size of slots, and the like. The values of these quantities are given in appropriate tables and curves, with examples to illustrate their use.

The information in this bulletin is a distinct contribution to the literature on universal motors, and should be of much value to any who are called upon to design, apply, or repair them.

Henley's Twentieth Century Book of Recipes, Formulas, and Processes

By Gardner D. Hiscox. Published by the Norman W. Henley Publishing Company, 2 West 45th St., New York, N. Y. Cloth board covers, 6x9 in., 800 pages. Price $4.

MORE than 10,000 recipes and formulas, from simple home recipes to complicated industrial processes, are given. The scope is indicated by the following partial list of subjects: Dyes, inks, waterproofing, perfumes, cement, plating, glass, dentifrices, varnishes, soaps, glues, paints, adhesives, enameling, oils.

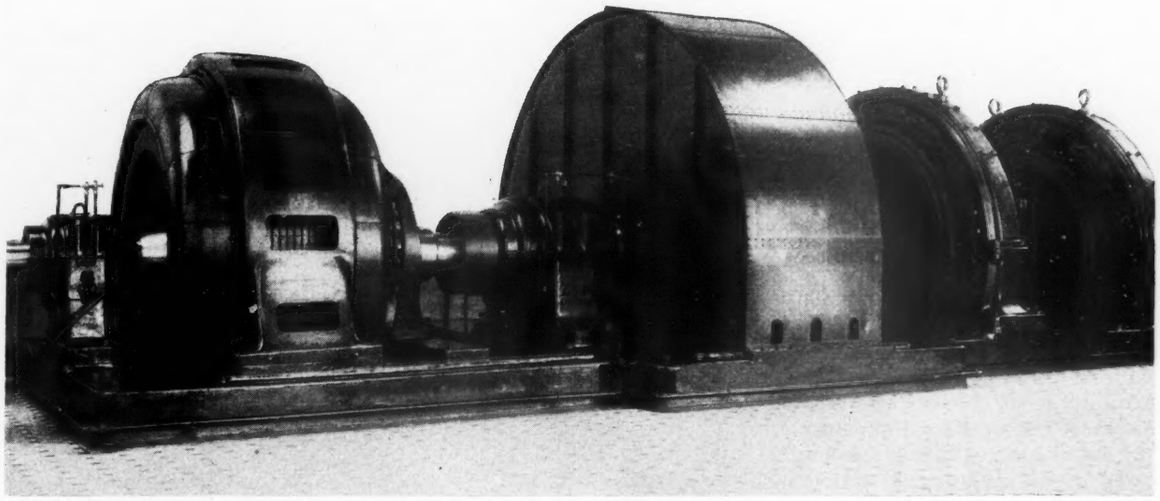
Earlier editions of this book are well known. The present edition is enlarged and its contents have been brought up to date. A chapter on useful workshop and laboratory methods has been added.

A Plant Engineer Defines His Job

E. W. ZIMMERMAN, in a recent issue of the *Sibley Journal of Engineering*, Cornell University, gives the following explanation of his duties as Plant Engineer of the Brown-Lipe-Chapin Division of the General Motors Corporation, Syracuse, N. Y.

"Plant Engineering presents many interesting problems, but probably the greatest is that of keeping abreast of the times on questions of all kinds of building maintenance and equipment. The job includes supervision of roofing, painting, boiler equipment and operation, heating, flooring, steel chip disposal, sewers and drainage, yard conditions, belting, drive shafting, conveyors, trucks, both hand and electric, electric equipment for light and power, installation of machines and many others. These problems are checked with others in the same line by frequent visits through other plants and by attendance at sessions of the American Society of Mechanical Engineers, Power Show, etc."

MATCH MOTOR *and* JOB



A 5,000-hp., 368-r.p.m., wound-rotor induction motor driving a flywheel motor-generator set for reversing mill service.

How to Choose the A.C. Motor for Specific Application

By R. H. WRIGHT

Steel Mill Engineer
Westinghouse Electric & Manufacturing Company
East Pittsburgh, Pa.

WHILE the many types of motor drive now available were passing through the early stage of development, there was often considerable discussion as to which one of two or more types of drive was best adapted to a given application. Now, with our better understanding of the requirements of various applications, we realize that each type of drive has characteristics which best suit it to certain applications.

For years, the use of synchronous motors was considered desirable because of their superior power factor characteristics, but because of the limited starting torque and high starting current the field of application was somewhat limited. The development of the use of synchronous motors for heavy-duty drives in steel plants is typical of the development in other industries.

When large a.c. motors were first used to drive rolling mills, power systems were comparatively small, thus making it necessary to limit load peaks as much as possible. The wound-rotor induction motor was widely used because it could exert a high starting torque with full-load input, or less, and when used with a flywheel and suitable control load peaks on the power system could be limited to any desired value.

Later, as heavy-duty reduction gear units became available, high-speed induction motors came into use because of the lower cost of a high-speed motor and gear unit, and the improved power factor. Power factor then gradually ceased to be a problem of real consequence in most steel plants.

By the time that geared drives were well established, steel plant power systems had become so large and the load so diversified that momentary peak loads on individual drives had very little effect. It was no longer necessary, in many cases, to use flywheels to equalize load peaks; nor was it necessary to limit starting peaks.

This condition made it possible to use synchronous motors for a great many applications; so when synchronous motors with improved starting characteristics were brought out a few years ago, they were freely applied. During the past five years 129 synchronous motors ranging in size from 300 to 9,000 hp. have been purchased in this country for rolling mill drives. Most of the motors of 1,000-hp. rating and above operate at slow and medium speeds and are directly connected to the mills.

The use of direct-connected synchronous motors gives mechanical simplicity without the poor power factor of the slow-speed, direct-connected induction motor. This is, perhaps, the greatest advantage of the synchronous motor for certain types of slow-speed drives.

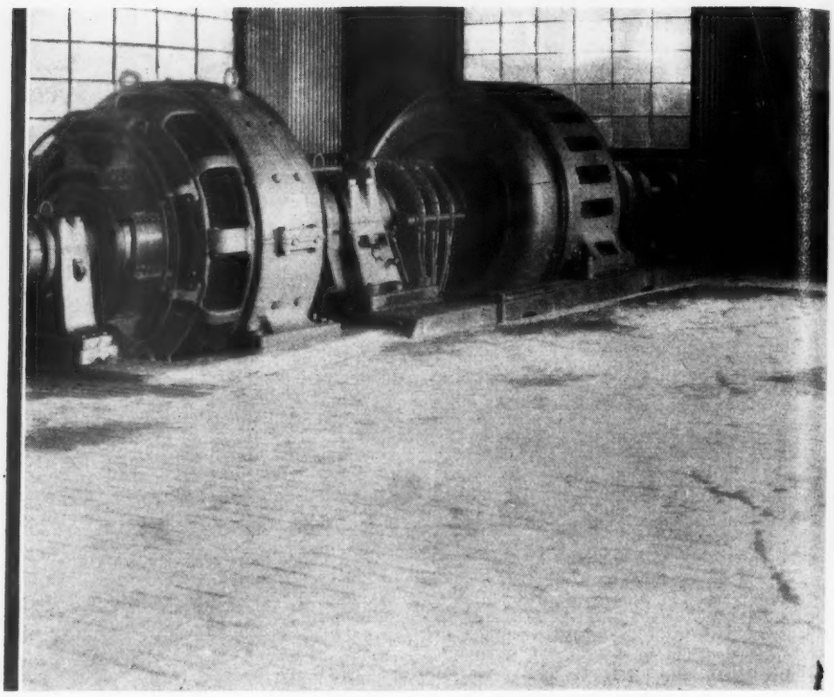
Large, slow-speed synchronous motors are usually designed for 100 per cent or 90 per cent leading power factor. The efficiency is usually 1 or 2 per cent better than with induction motors for the same speed. Efficiency at some particular point on the load curve may not be an important consideration where the load is highly fluctuating, but where the load is steady, high efficiency at the average load is desirable.

For example, continuous rod mills are sometimes laid out so that a constant-speed drive may be used for the rolls. The load on such a mill is practically steady and the mill may run for days at a time with only brief

shutdown periods. The energy consumed by the main drive will run up to 150 kw-hr. per ton of product rolled and a small difference in efficiency will be important. Synchronous motors are chosen for such drives because of their high efficiency, mechanical and electrical simplicity, uniform speed, and because they can be designed for any desired power factor.

On the other hand, seamless tube piercing and rolling mills do not consume a large amount of energy, but impose highly-fluctuating loads on the driving motor. It is common practice to design motors for this service for peaks of 300 per cent of the normal continuous rating. The normal duty cycle consists of a peak of 200 to 300 per cent of motor rating, lasting for ten to fifteen seconds, followed by a longer period at friction load. The duration of the load peak is too long to make the use of flywheels practicable. Again, the mill runs at slow speed and is best driven by a direct-connected, slow-speed motor.

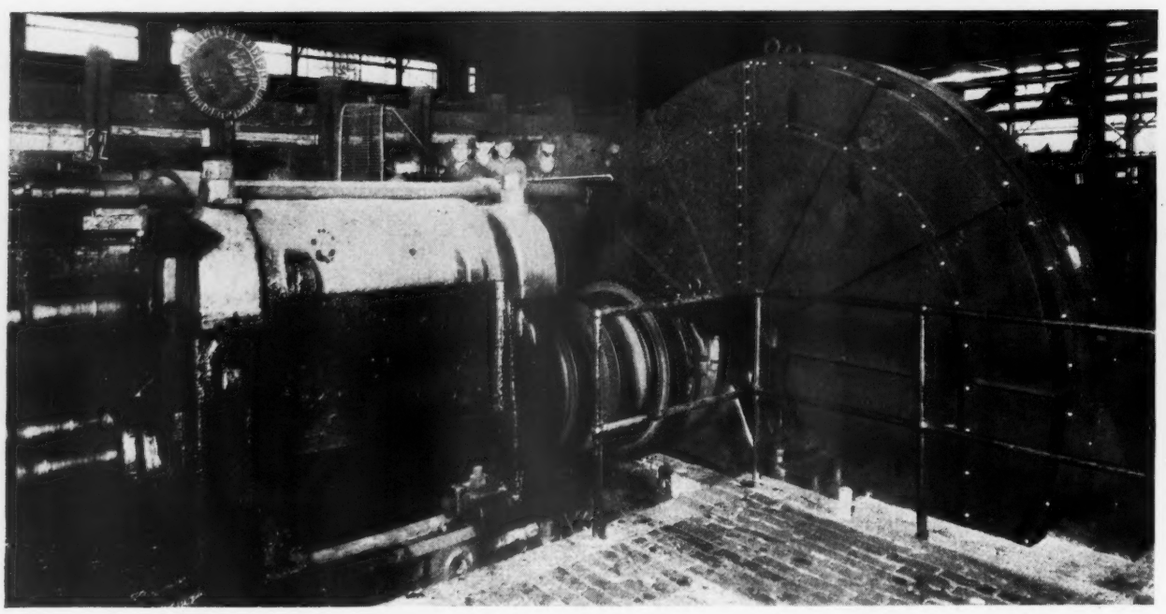
In selecting a motor which will permit the maximum number of operations per hour without overheating under these conditions, the important consideration is not the efficiency at rated load but the losses in the windings over the duty cycle. Here, again, the properly-designed synchronous motor with suitable control for varying the excitation to suit rolling conditions provides the best form of drive.



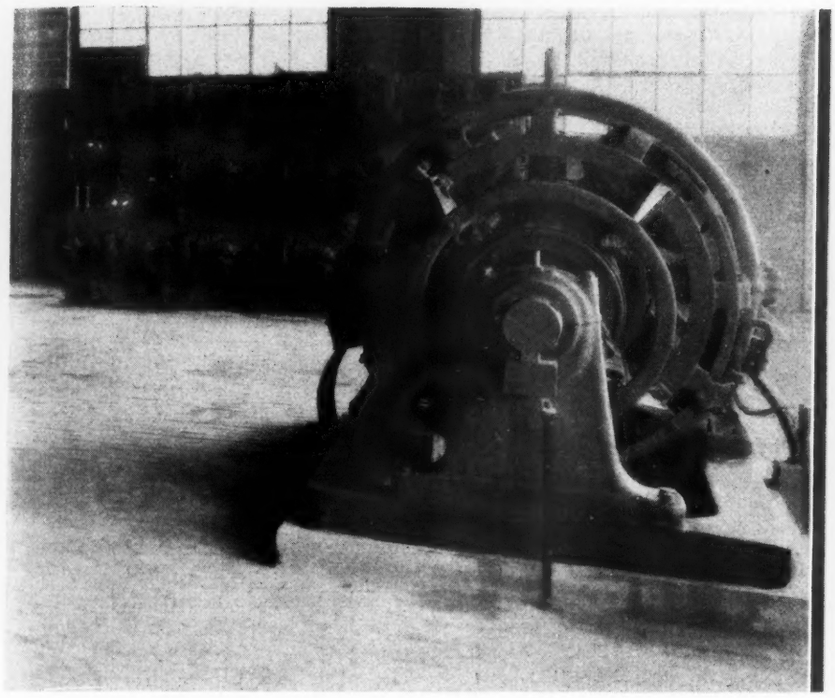
Constant-horsepower, a.c., adjustable-speed equipment, rated at 3,000 hp., 505/300 r.p.m. The 3,000-hp. induction motor and its speed-regulating machine are shown at the left. The control is in the background and the rotary converter, which converts the slip energy of the induction motor to direct current for the regulating machine, is shown at the right.

Synchronous motors are in general use for rubber mill line drives. Applied at first to improve the plant power factor, today they are used primarily because of their efficiency, adaptability for direct connection to the low-speed mill lineshafts, and because dynamic braking can be used to give quick stopping automatically in case of accident.

Synchronous motors up to 2,000-hp. rating and larger are frequently arranged for starting at full voltage. The starting inrush at full voltage will vary between 300 and 500 per cent of full-load kilovolt-amperes,



An 1,800-hp., 150-r.p.m., 6,600-volt synchronous motor direct-connected to a seamless tube piercing mill.



depending on the design. Synchronizing or pull-in torque can be varied from 40 per cent to more than 100 per cent of rated full-load torque.

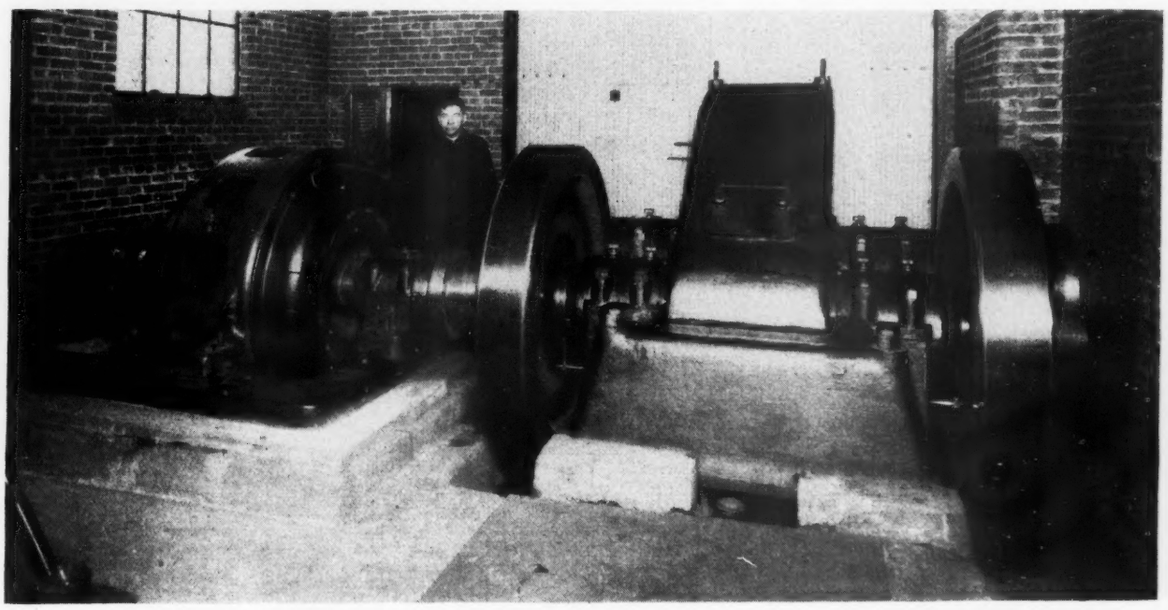
The control for full-voltage starting consists of a line contactor or oil circuit breaker and a field contactor for automatically applying the field at the proper time. Where the power system is large, motors of 2,000- to 5,000-hp. rating, and sometimes larger, may be started through a reactor that is automatically short circuited as the motor reaches synchronous speed. Control for reactor starting consists of a line circuit breaker, a reactor short-circuiting breaker, and an automatic field contactor. Where it is necessary to limit the starting current to the minimum, an auto-transformer is used. This method of starting requires at least three oil circuit breakers in addition to the field control, except in cases where a low-voltage starting bus is used.

The pull-out or stalling torque of an induction motor is definitely fixed by the design of the motor, but the pull-out torque of synchronous motors can be varied by adjusting the excitation. This feature is valuable where the load fluctuates widely, or where an occasional peak is higher than normal. Automatic control can be used to increase the excitation and raise the pull-out point for abnormal loads. In this way the motor operates with only normal excitation and with minimum leading current at light load, thus keeping the losses down.

Although the synchronous motor is applied only to constant-speed drives, the induction motor can be used either for constant-speed or adjustable-speed service. Alternating-current, adjustable-speed equipments may be built either for constant-horsepower or constant-torque output and may be designed for single-range operation only below the synchronous speed of the induction motor or for double-range operation, either above or below the synchronous speed. The motor is a standard wound-rotor machine, the speed and torque output characteristics depending on the equipment used to give speed regulation.

Alternating-current, adjustable-speed drive is used in rolling mill service where it is desired to vary the speed of a group of mechanically-connected roll stands. Equipments up to 7,500-hp. capacity have been applied for this service.

Another important field for a.c. adjustable-speed motors is the variable-ratio frequency changer. Induction motors up to 28,000-hp. capacity with double-range speed regulating



Geared motor rated at 400 hp., 705 r.p.m. driving a rolling mill. Flywheels on the pinion shaft equalize the load peaks.

equipment have been used for frequency changer drives.

Wound-rotor induction motors are used to advantage in combination with flywheels where the load consists of a series of short, heavy peaks which may be several times the average load. In general, the best applications are those where the load peaks are of less than five seconds duration and there is time for the motor and flywheel to recover the speed lost during the peak.

Large d.c. reversing blooming mill motors receive their power through flywheel motor-generators. A modern, 7,000-hp. reversing rolling mill motor can exert momentary peaks of 19,000 hp., but the induction motor driving the motor-generator is rated at only 4,000 or 5,000 hp. An automatic liquid slip regulator connected in the secondary of the induction motor causes the flywheel to equalize the load peaks and limits the maximum input from the power lines to slightly more than the full-load rating of the induction motor.

When a reversing mill motor drives a finishing mill the load is more constant and usually the peaks are moderate and of longer duration. For such applications a synchronous motor-generator may be used. The capacity of the driving motor is not determined by the average load, but by the root-mean-square load, as there is no flywheel to equalize peaks and the synchronous motor must be larger than the induction motor of a flywheel set of the same generator capacity.

Wound-rotor or squirrel-cage induction motors are especially well adapted to drive machine tools such as punch presses, shears, and board hammers, which operate intermittently. By proper design of the motor the kinetic energy of the moving parts can be utilized during the working part of the cycle to reduce the demand on the power system and likewise permit the use of smaller motors.

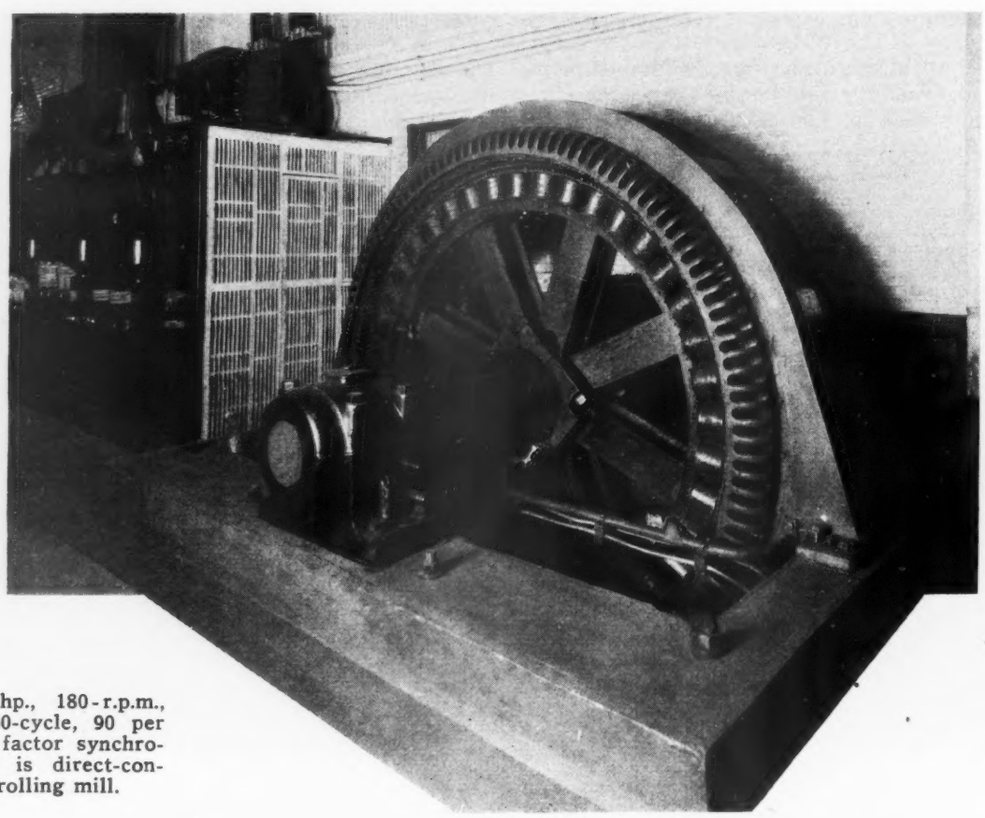
For high-speed service, such as centrifugal pump drives, the squirrel-cage induction motor compares favorable in performance with the synchronous motor, and has the advantage that no excitation is required and the amount of control equipment needed is reduced to the minimum. For these reasons the high-speed, squirrel-cage motor is frequently used for pipe line pumping stations. Synchronous motors are also used for this service, the choice depending on local conditions.

In applying a.c. motors it should be kept in mind that a wide range of operating characteristics is available and the motor and control for a given service should be selected so as to give the best performance of both the electrical equipment and the machinery it drives. Both synchronous and induction motors and their control are now highly developed and each type of motor has its own field of application.

Centennial of Weighing to Be Celebrated in July

TO commemorate the invention of the modern platform scale by Thaddeus Fairbanks in 1830, business and industrial leaders of the nation, as well as many foreign countries, will gather in St. Johnsbury, Vermont, on July 4, to pay tribute to the memory of Thaddeus Fairbanks, "father of modern weighing," who gave the world its first accurate standard of weights one hundred years ago.

The principal feature of the program will be an historical pageant depicting the progress during the last century in the evolution of the modern weighing machine and its influence upon human welfare and world commerce. There will also be an exhibition of original patent models of scales invented by Fairbanks, which have been borrowed for the occasion from the patent office.



This 2,000-hp., 180-r.p.m., 2,200-volt, 60-cycle, 90 per cent power factor synchronous motor is direct-connected to a rolling mill.

PLANT · ENGINEERS' · FORUM

* * *

Here is the eleventh of a series of questions, each of which has at least two sides. A new question will be presented next month, and our readers' answers to previous questions also will be published. Write down your opinions and send them to the editor. Answers published will be paid for at an attractive rate.

* * *

Do Distributors Serve Industry Economically?

Evidently George Shipman and Frank Fulleger had no mishaps in concluding the drive, during which we listened in on their conversation last month. At any rate both seem fit as we now find them on the public golf course. They are intent on their game but find time, while following their drives, to piece out a "shop" discussion. In spite of advice to the contrary that these two men have heard repeatedly they cannot entirely forget their work—they are dyed-in-the-wool shop men.

* * *

"Did you read about the Mill Supply Convention at Memphis, Frank?"

"Sure did. What are those distributors shooting at, anyway? Are too many plants buying direct from the manufacturer to suit them?"

"Putting it plainly, Frank, that may be a good analysis of the situation. But I wonder if they aren't justified in their stand? I'll bet that you buy from a distributor—or mill supply house—whenever you're in a hurry and order from a manufacturer when you have plenty of time. How long would your grocer last if you followed the same policy with him?"

"Wait 'til I sink this one, George. Where's the next tee? You're right concerning what I do. But isn't the distributor protected by his agreement with the manufacturer, so that he gets his commission even if I do buy direct from the manufacturer?"

"Sometimes yes, and sometimes no. Manufacturers are only human. If they get the bulk of their orders direct from the user how long will they continue to sell through distributors? And if the distributors disappear, what will you do in emergency? Where will you get the personal and engineering services that you now get from the industrial distributor?"

"Wait a minute, George. How about price? The manufacturer who sells direct frequently beats the distributor on price. Am I to hold the bag?"

"Well, that's one of the questions. In my humble opinion there are times when you should. The mill supply distributor certainly holds the bag for you many times—and for the manufacturer, too. He carries the inventory, in other words. What I mean is that he carries the supplies in his warehouse and that it's his money tied up in them. They don't lie in your storeroom and your money is free to earn for you. And I'll bet that you can think of eight or ten instances when some man from a mill supply house gave you equipment information that saved you a pretty penny and no end of trouble."

"Good gosh, George, do you mean to imply that I've got to step in and help settle this manufacturer-distributor problem? If the distributor is sound economically won't the question settle itself?"

"I don't say that it won't, Frank. In fact I think that most questions will settle themselves if given long enough. However, there are several ways of settling questions; war is one of them, and arbitration is another. In arbitration we get as close to the facts as we can, argue the thing out, and agree upon what seems sound economically. You know it's frequently the innocent bystander who gets shot when opposing factions resort to their artillery. If the user of supplies doesn't state his position he's likely to be caught short if the manufacturer and distributor war instead of arbitrate."

"Something in what you say, George, but if the personal service, the engineering service, the carrying of inventory, supplying on emergency, and so on count for so much, why don't the manufacturers get back of such a program, sell it to customers, and then back up their distributors?"

"That's the question, Frank, old boy. Does it mean anything to us, as buyers, whether they do or not? In other words, what are the facts so far as the equipment buyer is concerned? How the devil did you make

that hole in three? That's a birdie. Guess I've talked while you paid attention to the game. Took a five, myself. And we're back where we started in our discussion. No more shop for me today. I'm going to trim you on the second nine. Your honors—let's go."

* * *

If Frank and George talked long enough they might settle this question—to their own satisfaction. But the distributors and the manufacturers might not agree with them; and it might happen that other buyers of mill supplies might not, either.

This question concerning the position of the distributor in the economic scheme of things is very much to the front right now. You readers of "Industrial Engineering" are the buyers represented by Shipman and Fulleger. What do you say? Room will be found to publish all discussions that supply worthwhile information or opinion. Send your discussion in as soon as possible. And the opinions of the distributors and manufacturers of mill supplies will be welcomed.

Does the mill supply house, as a distributor, fill an economic function?

Is prompt delivery of supplies important from the maintenance angle?

Does close contact with the distributor's salesmen really mean anything to the user of supplies?

To what extent do supply houses render warehouse, or inventory service?

Do the representatives of distributors furnish operating information of value?

Are prices lower when supplies are bought from the manufacturer direct? If so, is the money saved enough to offset the value of distributor service, assuming that it exists?

What have been your personal experiences in buying from distributors and from manufacturers direct?

READERS' ANSWERS

to previous questions

How Big Is Maintenance?

(Question presented in the May issue)

I LIKE to look upon maintenance as being as big as the plant. I further look upon the maintenance engineer's duties and responsibilities as being second only to the manager's.

The production department is usually divided into several specialized departments, each one knowing little about the other fellow's problem and less about his machines, whereas the maintenance department has to take them all under its wing and know a great deal about their operating methods, as well as the machines.

It is impossible to mention all of the maintenance engineer's duties, but a few picked from among the many will be sufficient to show the broadness and importance of maintenance.

The maintenance engineer is responsible for the conditions of trucks and unloading platforms, and storage of the raw materials as they enter the plant.

He is responsible for the conveyors, hoists, cranes, and elevators, and other means of handling material to get it started along the converting line of production.

Next, he has to supply the power, the transmission equipment, the water and steam, and often means of automatic control of the manufacturing processes to enable the finished product to meet a given standard.

Often he will have to provide means of transferring the materials from one operation to another in a molten or heated state.

Then, too, he is called upon anytime there is a break, or abnormal condition in the line of production, to solve the problem of bringing back a normal state of operation.

The maintenance engineer is further responsible for providing means and ways of getting the finished product from the machines to the outgoing cars.

A few more items are: Provide proper repairs, in order to keep the equipment and machinery in good operating condition.

Investigate machinery and equipment removals, when suggested by the production department, to ascertain the advantages. In case the removal is warranted or approved, he has to provide the place, do the setting up, and put the equipment into operating condition.

Look after building maintenance, including the maintenance of roofs, floors and walls; watch the overloading of floors; take care of the painting of the building, interior and exterior, and the painting of equipment.

In some cases he will be required to design and erect new buildings, for replacement or expansion. He may be required to make layouts of machinery and material handling installations, and lighting and power lines.

In many cases he will draw up specifications for and requisition new machinery, equipment, and supplies.

He must maintain all fire-fighting equipment.

The maintenance engineer is obliged to: Plan and keep in operation an effective system that will insure all equipment, machinery, and fire protection apparatus, and buildings being regularly inspected, to catch any impending troubles before failure occurs.

Keep abreast of developments in equipment and machinery, and material handling and manufacturing methods.

Know when a machine has become obsolete, through having served its useful life.

Select proper lubricants and their method of applications.

Provide proper heating and ventilating, also proper working conditions.

Make tests on equipment and machinery in operation to determine its efficiency.

Make estimates for new work and improvements.

See that buildings, equipment, and machinery are properly cleaned.

Assist the safety engineer in maintaining accident prevention activities throughout the plant, such as safety guards, the removal of accident hazards caused by worn machinery, belts, flywheels, pulleys.

Maintain signals and lines of communication as time saving devices between departments.

Surely a department which has to follow the raw materials from the unloading car through the converting operations to the shipping cars, and in the meantime maintain the production machinery and equipment, should be second to no plant function other than management.

MARIN PHILLIPS, *Electrical Superintendent*
International Paper Company
Niagara Falls, N. Y.

Should Maintenance or Production Department Control Cranes, Elevators, and Trucks?

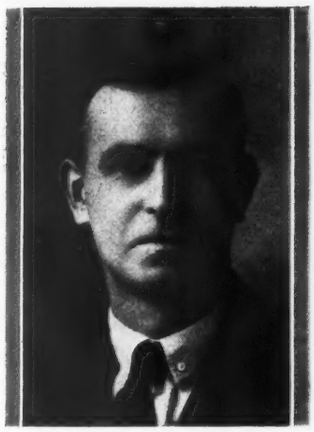
(Question Presented in the April Issue)

OPERATION of cranes, elevators, and trucks can be controlled best by the production department. The maintenance work should be delegated to the one department best fitted for such work—the maintenance department.

The operation of inter- and intra-plant transportation of materials should be systematized, and the production department stands in a better position to make pertinent studies to determine the best method of operation. To handle inter- or intra-shop transportation successfully, the production department first studies the materials that have to be handled and classifies them into analogous groups, with knowledge of the quantities to be handled. Next, the routing of raw materials, products, subassemblies, final assemblies, containers, etc., is studied to know what materials or groups of materials are to be moved and from what point to what point. If the product is standard and uniform and the processing is continuous, it is not difficult to secure all necessary information to set up a plant transportation system.

It is good practice to have the transportation section head directly responsible to the production manager. This foreman looks after dispatching of tractors and trains, maintenance of his own equipment, and so on.

The plant transportation foreman frequently is asked to assign permanently one or more tractors and perhaps certain trailers to a given plant or department, in which case the driver reports directly to the foreman of that department for operating orders, but is under the transportation foreman so far as maintenance and care of equipment are concerned. Dispatching is done in some cases by scheduling and at a given time the tractor driver appears, cutting off certain trailers and taking certain others, or transfering material, as the case may be. Where the product is standard, production is uniform, materials going to a given production center and being taken therefrom are in definite quantities, and regularly, periodical dispatching can be done. In the majority of instances this cannot be done and dispatching is handled by means of automatic telephone, telauto signals, or other suitable means.



CHARLES H. WILLEY,

head of the manufacturing department, Hoyt Electrical Instrument Works, Penacook, N. H. His discussions are bound to give the production as well as the plant engineering slant.

In large industrial plants, such as automobile or packing plants, material frequently can be regularly scheduled. Here the entire plant is divided into sections with a dispatcher's office in each section. The dispatcher requisitions enough trailers and accumulates them at the proper time together with tractor to haul. As a result of such scheduling, material is not sidetracked or moved to the wrong department. All plans are made ahead of actual movement of material.

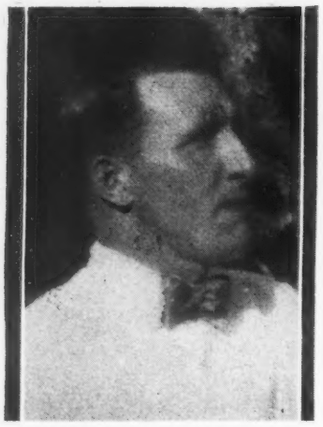
The production department makes plans, scaling distances between buildings, and prepares a table giving distances of regular truck routes between any two points. Tests are then run and tonnage and distances for each truck are recorded daily during the test.

From these data, routes, dispatching points, and schedule can be worked out by the production department. This information is transmitted to the foreman of the transportation section, the proper schedule having been worked out, and the operation of trucks and other means of transportation being handled by the production department through the transportation foreman is efficiently controlled and accomplished.

GEORGE H. GUNN, *Maintenance Section*
Engineering Department
Naval Aircraft Factory, Philadelphia, Pa.

SHOULD the maintenance or production department have charge of the operation of cranes, elevators and trucks is a question that has been tried and decided in our plant.

A few years back, after having passed a rather peaceful era of operation under the production department, the cranes and elevators were put under the maintenance department with not very good results.



MAURICE C. COCKSHOTT

of the J. B. Gill Corporation, Long Beach, Calif., who has had a wealth of maintenance experience and who is glad to give the benefit to other engineers.

Possibly the poor results were due to our own improper handling; however, I find that the men engaged in maintenance work do not like to sidetrack, so to speak, to run cranes and elevators, or the like.

As I see the maintenance department, it should not be bothered with details of handling materials, other than to see that the handling equipment is running as nearly 100 per cent as possible.

To have the operation of the cranes, etc., under the maintenance department means that the head of the maintenance department must familiarize himself with the operating conditions of the department affected by the operation of the equipment in question to such an extent that I doubt whether he would have much room in his head for his real duties.

Of course, that leaves open the question of a large enough maintenance department to handle this work properly, but that, to my mind, would be a duplication of the knowledge necessary for the head of the operating department to have.

There is just one limitation I would put on the operating department, which is that whenever the department in charge of maintenance sees fit to remove from service any piece of apparatus it should have authority to do so notwithstanding complaints from the operating department. The maintenance department head should be competent to say when apparatus is in bad enough shape to be taken out of service during operating periods.

Looking at this question from the standpoint of the operating department, it has been our experience that the operating department will not shut any thing down until failure occurs.

In order that readers may more intelligently compare our plant equipment and methods with that of others, the following data are furnished: We have in operation 13 combination freight and passenger elevators, 45 cranes, and 19 electric trucks. This equipment is handled as follows:

Elevators are operated by the departments which they serve, the operators being supplied by the operating department.

Cranes and their operators are handled by the departments they serve.

Most of the electric trucks are handled by the stores department; however, there are a few departments that operate their own trucks and supply their own drivers.

In all the cases mentioned, the electrical department is responsible for the operation of the equipment from a maintenance standpoint. The electrical department in our plant does not have in its organization any millwrights; however, the millwright department works under instructions from the electrical department whenever any of the equipment mentioned is affected.

The maintenance department should have a great deal to say as to what type of equipment is ordered for the production department, keeping in mind the type of service required of that equipment.

What I am getting at is this: Just because some salesman happens to have a good enough line to sell the head of a production department an a.c. crane or hoist is no reason why it should be purchased.

We have to some extent standardized on certain types of equipment, and to have a production department order different equipment over our system means delays in repairs and a larger storeroom stock than would otherwise be necessary.

W. B. Ferguson, *Works Electrical Engineer*
Westinghouse Air Brake Company
Wilmerding, Pa.

How Shall Equipment Be Purchased?

(Question Presented in the February Issue)

PROBABLY the most important items to consider are standardizing, first cost, cost of installation, and speed of delivery and installation.

Greater economy lies in purchasing equipment that is interchangeable and for which spares can be kept at a minimum. This is one point in favor of purchasing equipment by separate units against the purchase as a whole unit, unless the manufacturer can comply with the customer's requirements in this respect.

Direct-connected pumps afford an example of equipment that can be bought in separate units and not cost any more than if bought as complete units. The best plan is to order the pump and motor separately, have the motor shipped to the pump manufacturer for mounting on a common bedplate, and finally shipped as a complete unit to your plant.

Regarding the selection of units, the manufacturer should be capable of selecting as good equipment as that designed by himself, and in these days of keen competition usually does, since the day of "let the buyer beware" is past.

Assembling equipment by the customer's mechanics is not always a way of saving money. There are exceptions to every rule but, for the most part, an intricate machine is best assembled by the manufacturer who maintains an efficient and skilled force for that purpose. Use of the customer's mechanics, working under the supervision of one skilled representative of the manufacturer, seems to offer a better solution than customer supervision.

There are a few cases where greater savings can be effected if the entire erecting crew is supplied by the manufacturer. These instances apply where all skilled mechanics are required. Most large manufacturers maintain an erecting department consisting of from one to several crews, depending on the output and size of the plant. These companies prefer to erect, or at least to supervise the erection of their equipment, but as a general rule do not care to assume responsibility

unless the equipment is of their own manufacture. As a general rule, their charges for supervision and erection are based as a percentage of the total installation and will vary from 5 to 10 per cent of the cost of the equipment.

There are instances, however, where the cost of erection can be materially reduced. A few of these instances are here given. The writer was called to erect a high-tension substation where the transformers were purchased from one manufacturer, the high and low-voltage switching equipment and lightning arresters from another, and the synchronous condensers and panels from a third. One manufacturer agreed to install the complete equipment for a specified sum, but would assume no responsibility for the satisfactory operation of equipment other than his own. The writer made the complete installation, without a hitch, with a saving of approximately 4 per cent to the customer.

Another instance where the cost of supervision and engineering was reduced from 4 per cent to 1.5 per cent was the erection of a 6,500 kva. station serving a pulp and paper mill. The crews that made the complete installation of motors and equipment, approximately 9,000-hp. connected load, were employed by the customer and the installation completed on time. The customer, of course, assumed all responsibility for the erection, but the savings plainly showed he was justified. H. E. STAFFORD, *Electrical Engineer*
Port Arthur, Ont.

T. A. KEEFER, head of factory layout department, National Cash Register Company, Dayton, Ohio. His discussion is backed up by experience.

Who Shall Do the Salvaging?

(Question Presented in the December Issue)

THE salvage department is important, and, in those institutions where a plant engineer's organization is highly developed, we find this department coming under his jurisdiction. In smaller plans, the maintenance men handle this work. A separate department is organized in the larger factories for the disposition of waste and salvaging of those portions of machinery that are usuable again. The plant engineer's department is responsible for machinery and its maintenance and consequently should be responsible for determining whether a machine is to be kept in storage for re-use or discarded as junk.

It has been the writer's experience that the following set-up works out very well. Materials of a salvage nature which can be sold to outside concerns should be handled in a cooperative manner between the plant engineer's department and the purchasing department. The plant engineer decides upon the items to be discarded and sold, and those that are to be kept. Standard salvage materials such as paper, sawdust, and manufacturing waste, are, after certain specifications are developed by the plant engineer's department, sold to outside concerns, and contracts are made to take care of their disposition.

All machines that are not in actual use are kept in the machine stock room. Here they are carefully inspected and those which are to be disposed of are sold through the cooperation of these two departments. A price is set and the customer is located by the man in charge of second-hand machinery. When a machine is not fit for re-sale, the maintenance department (which is also a part of the plant engineer's organization) strips the machine of all usable parts. These parts are kept in a separate stock and no charge is made except that the equipment is held on memo.

Strict orders must be issued for the operation of the second-hand machine room. The room is under the care of one man and is kept locked at all times.

Whenever a machine is salvaged from the factory and is in fairly good condition, it is repaired, cleaned, and put into stock to be shipped out again for future use. The cost of repair is charged against the department from which the machine came. This system applies to motors, production machinery, and mechanical supplies (such as pipes, fittings, valves) as well as transmissions, which include belting, pulleys, shafting, hangers, and couplings. All small parts and machines are placed in racks provided for the purpose, and are carefully classified and indexed so that it is possible to tell at a glance what is in stock when requisitions are received from the factory.

We have tried several systems in managing our machinery. We even allowed each individual factory to handle its own spare machine parts and salvage operations. Our last experience, however, has been most successful. We placed the responsibility for the salvage of equipment with the plant engineering department which is familiar with all the machinery used in production work. We also found that by having one central storeroom, where machines are shipped from all factories, the work is carried on more economically and under the proper control, which assists not only in the reclamation of machines but facilitates the re-sale and salvage of parts and machinery.

I believe that it is more satisfactory to concentrate the sale of salvage materials such as baled paper, sawdust, shavings, machine scrap, and broken parts with one or two responsible companies. These concerns will render better service and provide steady collection schedules when sufficient business can be obtained by pooling all materials.

It is necessary at the writer's plant to clear up this material each day as we do not care to have it accumulate in the factories. It is desirable to have a reliable party handle this work—one who will remove the material from the premises regardless of time, weather, or other conditions. We therefore contract with one concern to carry out this work.

K. D. HAMILTON, *Mechanical Department*
Geo. E. Keith Company

Practical Solutions of Difficult Drive Problems

By WILLIAM STANIAR

Mechanical Power Engineer
E. I. Du Pont de Nemours & Company
Wilmington, Del.

REGARDLESS of flow sheets and routing diagrams in new plant layouts and all manner of precautions in the revamping of old plants, drive problems that are unusual and difficult are frequent. Such perplexities of power transmission are generally brought about by a change in process, or by additional apparatus of peculiar drive requirements. Mechanical drive installations are seldom identical, but, as power transmission is accomplished either by some one method or by a combination of methods, practical solutions of problems in one field of operation can be applied to others.

Difficult drive problems and unusual drive problems are not synonymous, because, based on the mechanical and atmospheric conditions involved, a drive may be difficult but not unusual. This statement is particularly correct with belting installations. The average belt drive is not unusual, but some installations can be extremely difficult when the wrong type and size of belt are employed. For example:

A belt-driven mixing machine, as shown by Fig. 1, handling a heavy viscous product, was selected to operate 30 min. in one direction, then stop and operate 30 min. in the opposite direction, and so on. For a 500-lb. charge in the machine 30 hp. was required. The driven pulleys of the machine were 48 in. in diameter by 6 in. face, operating at 110 r.p.m., resulting in a belt speed of 1,350 f.p.m. from a driving pulley 16 in. in diameter by 20-in. face. The reversing requirements necessitated two belts, one open and one crossed, and space limitations held the width to 6 in. Allowing 70 lb. effective pull per inch of width the maximum horsepower obtainable with a 6-in. double oak leather belt was 18 under normal tension. The speed necessitated extremely tight belting, but regardless of high tension on the oak belts it was not possible to pull more than a 300-lb. charge in the machine.

A re-design of the drive was not convenient, therefore, the problem was to find a belt that would pull a 500-lb. charge under the existing conditions. A combination tannage leather belt was finally employed because its ply of special tannage leather against the pulley greatly increased the pulling power. Its outer ply resisted the transverse crumpling action of the shifter forks. This type of belt successfully pulled the 500-lb. charge without excessive tension.

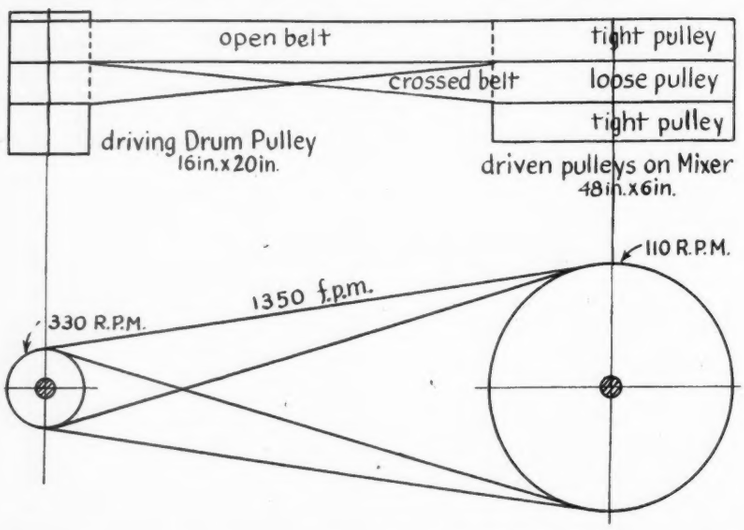


Fig. 1—The problem in connection with the belt-driven mixer handling a heavy viscous material was to find a belt that would pull a 500-lb. charge in one direction of rotation for 30 min. and in the opposite direction for a like period.

Loss in production, high maintenance, and premature destruction of belting are frequently caused by the repeated use of belting on slow-speed operations because of the inconvenience and expense of removing existing transmission arrangements. As an example, repeated attempts were made to drive a battery of four pulverizing mills from a line shaft by belts, individually shifted, as shown by Fig. 2A. Each mill required 12 hp. The belts were 6-in. double oak leather, the maximum width possible. Each belt extended from a 14 in. diameter by 12 in. face pulley on the line, almost vertically on short centers, to 30 in. diameter by 6 in. face, tight and loose pulleys on the machines. The machine pulley speed of 60 r.p.m. resulted in a belt velocity of approximately 450 f.p.m. which allowed 5.7 hp. capacity to the belting. After many failures the oak tanned leather was discarded and combination tannage leather belt substituted. This change raised the capacity considerably but not enough to pull the full load of 12 hp. without tight belting and excessive slippage because of the low belt speed. Belt after belt was ruined and low production continued until the idea of belt driving was finally abandoned.

Belt driving an installation of this character should not have been attempted because it was practically impossible to provide sufficient belt width to keep the effective belt pull within the allowable limit.

Relatively high capacity and low speed should be negotiated by mediums of transmission that possess

high tensile strengths, flexibility, and freedom from slip. The power chain is qualified for high-capacity, low-speed service because it has the foregoing characteristics. A chain of the finished-steel roller type operating on cut-tooth sprockets was substituted for belting and controlled by friction clutches on the installation under discussion, as shown by Fig. 2b, with the result that no further difficulty was experienced.

Solving the following unusual problem caused by space limitations and control was accomplished by the adaptation of a quill to a worm-gear reducer. A procedure not standard, but practicable in this instance. In an existing manufacturing department, it was necessary to install and individually control a battery of six vertical, open-top, mixing tanks, each requiring 3 hp. Space was not sufficient for group driving, and fire hazard prevented individual motor connection; therefore, the problem was to drive from a remote motor, individually control the power application, and supply the required speed reduction. It was obvious that the vertical shafts of the mixers had to be connected to a horizontal driving shaft by a worm-gear reducer because of the slow speed of the mixers. The drive shaft had to be driven at a practical speed from a belt-connected motor located in a safe location.

However, the real puzzle was the control. A quill, in reality, is a sleeve of a clutch supported by two bearings independent of the main driving shaft. When the clutch is not engaged the quill remains idle, allowing the driving shaft to revolve freely because of the clearance between the shaft and the bore of the quill. In view of these characteristics it was feasible to adapt such a device to a worm-gear reducer.

Instead of cutting the worm of the reducer integral with a solid steel shaft, it was cut integral with a hollow steel quill, the driving shaft being connected to the quill by means of a clutch. The assembly of this worm and quill arrangement employed in this case is shown in Fig. 3.

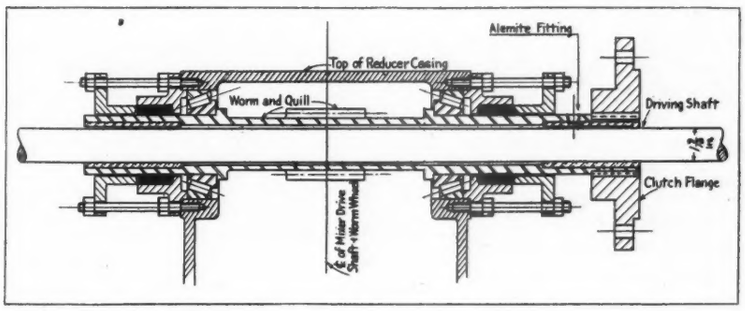


Fig. 3—Assembly of worm and quill employed in the operation of a battery of slow-speed mixers. The final arrangement provided for individual friction clutch control.

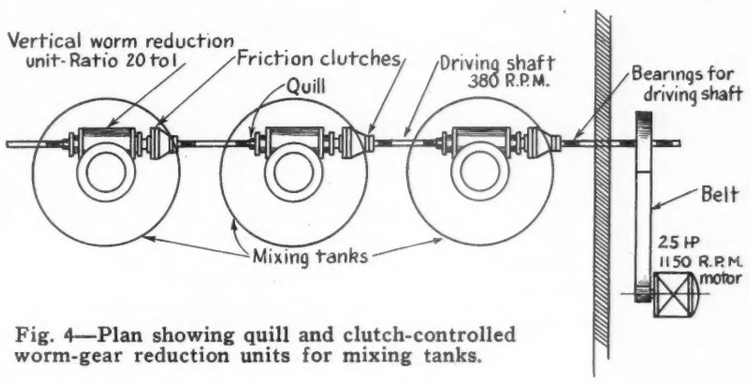


Fig. 4—Plan showing quill and clutch-controlled worm-gear reduction units for mixing tanks.

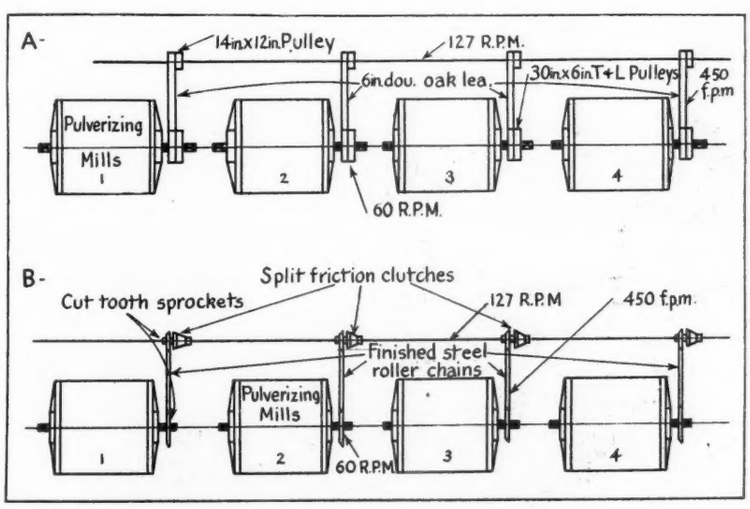


Fig. 2—In *A* (above) continuous trouble resulted in trying to operate the drive with belts that had to be shifted. After repeated failures the drive was arranged as in *B*, resulting in satisfactory operation.

It will be noted that the main driving shaft passes through the quill and that the clutch flange or hub is keyed to the quill. The required roller bearings and packing glands were easily applied. This arrangement allowed efficient individual friction clutch control and resulted in a closely coupled integral driving method. The main driving shaft from the motor was continuous through the six worm-gear reducers and was independent of the speed reducers as to support. A plan view of the layout in part is shown by Fig. 4.

Ratios of 250 to 500 to 1 from power source to application are common occurrences, but a 5,000 to 1-ratio in close quarters is a different matter when it must be provided without the expenditure of a large amount of money. A large diameter concentrating pan, requiring 10 hp. to drive it, was installed in a certain building where just about enough space was available to receive it. The stirrer in this pan was to make one complete revolution in 5.7 min., and it had to be driven from the bottom. Also, there had to be a belt somewhere in the driving layout to act as a break-pin if solidification of material took place in the pan during the stirring. The problem, therefore, was to drive the stirrer at a speed of 0.175 r.p.m. from the bot-

tom with inexpensive equipment and utilize a belt at some point in the transmission arrangement.

For economical reasons, a motor speed of 860 r.p.m. was selected, which resulted in a ratio of 4,914 from power source to application. A compound, single-case, worm-gear reduction unit, necessary for such a ratio, was not feasible because of space limitations between the bottom of the pan and the floor. Two single-worm reduction units closely coupled in tandem could not be employed for the same reason. Therefore, it was necessary to use two single-worm reduction units arranged and connected to suit the space available. The clearance between the bottom of the pan and the floor was sufficient for the installation of a worm reduction unit arranged for vertical drive, but the area occupied by the pan and the required belt drive between the motor and the first worm reduction unit necessitated a right-angled connection between the first and the reduction second unit.

This problem was solved as shown in plan by Fig. 5. The 10-hp. 860-r.p.m. motor was belt connected on a 3 to 1 ratio to the first worm reduction unit, resulting in a worm speed of 286 r.p.m. As the ratio of the worm unit was 40 to 1, a speed of 7.15 r.p.m. was obtained at the worm wheel shaft. This shaft was extended and connected to the worm shaft of the second vertical worm-gear reducer by means of miter gears. As the ratio of the second reducer was also 40 to 1 a speed of 0.175 r.p.m. was obtained on the vertical or worm-wheel shaft, which was the required speed of the concentrating pan impeller. For a total ratio of almost 5,000 to 1, the drive, although unusual, was entirely satisfactory.

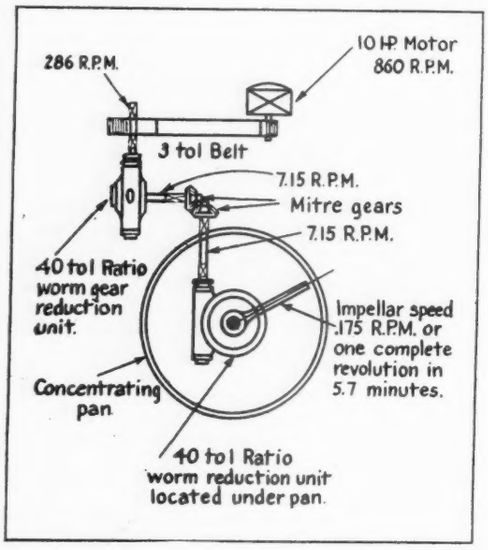


Fig. 5—Drive requirements and space limitations were responsible for the utilization of the equipment shown. The plan shows the possibility of employing high ratios at minimum expense.

The solution of difficult and unusual short-center drive problems has been greatly simplified by silent chain, multiple rubber, and fabric V-rope installations. The multiple V-rope, however, has been the greatest benefactor because of its adaptability to almost any problem of short-center work, and its low maintenance.

A certain plant was using a 600-r.p.m. generator (what is termed a slow-speed unit) which was driven from a water wheel. The vertical shaft from the wheel revolved at 110 r.p.m. This shaft was connected to a horizontal line shaft through heavy bevel gears and the generator was driven from the horizontal line by means of a belt. The installation of a high-speed generator became necessary, but with the driving facilities available, it was not possible to obtain 1,200 r.p.m. on the high-speed unit. This problem was solved by the use of the multiple V-rope drive operating in a vertical plane. The horizontal shaft with its heavy accessories and the bevel gears were discarded. A V-rope sheave of proper diameter was installed on the vertical shaft from the water wheel and connected direct to the 1,200-r.p.m., 93-kw., 60-cycle, 2,200-volt high-speed generator by means of 17 V-ropes as shown in Fig. 6. This installation has given perfect satisfaction in the form of constant speed, low upkeep, and silent operation.

Fig. 6—An unusual high-speed generator drive problem solved by the use of the multiple V-belt system.

AROUND *the* WORKS

THIS SECTION is especially devoted to short articles describing ideas and practical methods devised to meet particular operating conditions. The items may refer to mechanical details of installation, inspection, testing, wiring, repair, maintenance, replacement, and emergency or unusual installations of equipment tributary to production. Special attention is given to shop or bench tools and short cuts or improved methods of handling work brought into the repair shop. Contributions from our readers are always welcome.

Emergency Repair for Motor Starter

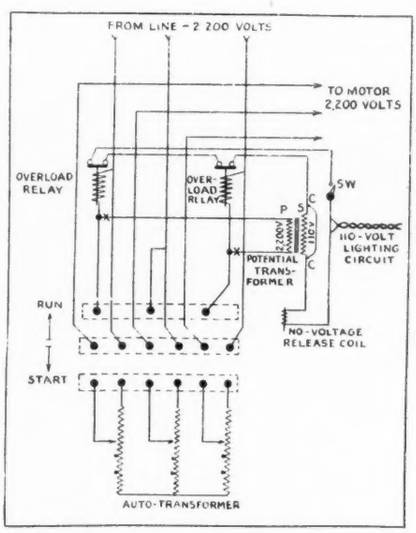
IN a certain type of auto-starter used on a 50-hp. induction motor, the potential transformer furnishing energy to the no-voltage coil "went bad," that is, the primary burned out. This meant that a complete shutdown for the entire plant was imminent, and to obtain another transformer would have required several days, at least.

Obviously this was an emergency. In looking around for nothing in particular, as is always done in cases of emergency, we remembered that the lighting circuit came from the power lines through the usual step-down transformers. And so the trip coil's energy could be obtained by connecting directly to the light socket.

This arrangement gave complete overload protection to the motor and practically the same under-voltage protection since the same voltage fluctuations exist proportionately in the secondary or lighting circuit as in the primary or power circuit.

The accompanying diagram at the bottom of the page shows clearly how this was accomplished.

Magnolia, Miss. W. T. CLAYTOR, JR.



When the primary winding of the potential transformer failed, a jumper was placed across its secondary and the lighting circuit connected, as shown, to operate the control devices.

Uneven Clutch Surface Reduced Transmitting Power

A MAGNETIC clutch designed to transmit 600 hp. at 600 r.p.m. gave trouble through slipping at heavy loads before its maximum transmitting power was reached. On examination, the winding was found to be correct, but on testing the magnetic flux at different points on the pole face the magnetic strength was found to vary considerably.

Dismantling the clutch, the pole faces were painted with red lead and then let down on the clutch surface in the position it would hold when working. In withdrawing, the marking showed that the gap was far greater on one-half of the circumference than on the other. This was due to one face being recessed deeper on one side. The reduction in the working surface caused the slipping on heavy loads. After the air gap was equalized by machining the recessed face there was no more trouble. W. E. WARNER.

Brighton, England.

Calculating Drum Cables

WE were hunting for a formula for finding the amount of cable take-up of a large drum for a unit of distance of rise of differential drum, and as the handbooks did not give any, I boiled one down. The sketch shows a differential drum suspended by two cables. The power factor being an inverse ratio to the velocity ratio when ignoring mechanical efficiency gave us our lead. The formula was deduced as follows:

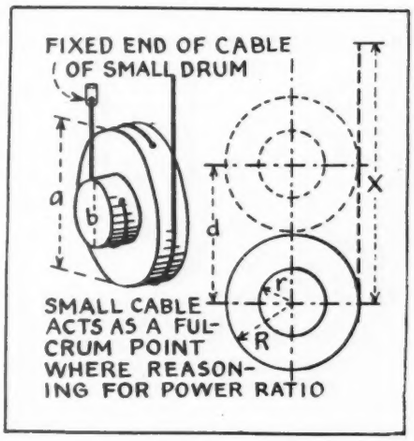
a = Diameter of large drum
b = Diameter of small drum

$$R = \frac{a}{2} = \text{Radius of small drum}$$

$$r = \frac{b}{2} = \text{Radius of small drum}$$

d = Distance of rise of drums
x = Take-up of cable of large drum

$$x = \frac{R}{r} d + d$$



Sketch of differential drum suspended by two cables, from which formula was developed.

This arrangement is sometimes used to obtain a higher power ratio through the differential drum when used as a sheave block. That is to say, the rise of the drums would be the desired final lifting power. ARTHUR A. CRAVEN.

In *Product Engineering.*
Marion Steam Shovel Company.

Electrical Trouble Traced to Mechanical Defect

EVERY electrician knows that all electrical troubles are not caused by defective electrical equipment or wiring. They know of many instances where the troubles were caused by mechanical defects.

Not so long ago I found a case of this kind which was hard to locate because the men operating the machine, and the mechanic that kept-up the machine insisted that it was in perfect condition. Not being detailed to overhaul the machine, but to find the trouble with the motor, I did not care to take the machine down and thereby inspect every part. I was sent in to correct all defects of wiring, motor parts, and control.

This machine was a planer used for cutting stone, and it operated day and night. As in most planer trouble, the machine would cut at the usual speed but the return would drag or run slow. Its a. c. motor was rated 15 hp., 1,800 r. p. m., 220 volts, and was mounted on the top of the machine. It had a chain connection to the jack shaft, and shipper-rod, reversing-belt system. The wiring was not entirely metal encased. An oil-filled hand compensator, fuses and overload relays were supplied with the installation.

In seeking the trouble, the motor was examined first. After the starter,

fuse clips, and the line fuses at the distribution board had been examined, an ammeter was wired in its circuit. The planer was started, but the retarded action on the return stroke continued. The ammeter readings indicated that the motor was not overloaded.

On the return stroke the current would run up as high as 65 amp. After spending an entire night checking and remedying everything in the electrical equipment, a mechanic was summoned. He examined all parts and pronounced them O. K. I found out later that he was a contract mechanic, who had just finished overhauling the planer. Naturally, it would have been hard for him to find anything wrong, mechanically.

It was decided to keep the motor in service and, two weeks later the real trouble was located. The loose pulley on the cutting drive was galled and was found to be have been running without lubrication all the time. When the high-speed return stroke was started this series of belting and gearing made a very efficient brake.

Birminghan., Ala. GRADY H. EMERSON.

Using Graphite in Bearings to Improve Operation

THERE are certain times when the use of graphite in bearings is clearly indicated as a very simple and convenient method of overcoming serious difficulties. For example, where a motor is too small for the job, or where the static friction is exceptionally high, difficulty may be experienced in starting up. This difficulty may be increased by the voltage drop in the circuit due to the heavy current rush at the start. As the starting torque of an induction motor varies as the square of the voltage it is obviously important to have good voltage regulation at such times. The combination of heavy voltage drop and high starting torque required to overcome high static friction may lead to overheating of the motor, and damage to the insulation.

Another instance where graphite is frequently very valuable for emergency use is when a machine is heating up on account of a rough bearing. Bearing troubles are especially likely to occur during the summer months. The higher temperatures of the machine and the surrounding air, and the lower viscosity of the lubricant, combine to bring about rapid heating of the oil with a corresponding decrease in viscosity.

By using deflocculated graphite in the lubricating oil it is often possible to counteract the decrease in viscosity due to higher lubricant temperatures. The use of graphite in this way is also a very convenient means of using oil which is supposed to be "worn out," but which really needs filtering.

Deflocculated graphite, when added to lubricating oil, fills up the slight irregularities in the bearing surface, thus lowering the friction. It helps to retain the oil that might otherwise be crushed or squeezed out from between the shaft and the bearing because it has insufficient viscosity for the job. In this way an oil that is too thin for the task may be made to suffice during heavy loads, especially in hot weather.

If the graphite is added while the shaft is rotating, the graphite will be thoroughly mixed with the oil and distributed over the bearing. If a bearing heats it is important, of course, to be able to apply the graphite without stopping, as a shutdown may not only not be permissible, but should it occur, starting up again may be impossible until the bearings have been repaired.

The best results are obtained by using only the smallest amount of deflocculated graphite. Experience indicates that about 0.5 per cent of graphite by bulk gives the best results. This quantity will reduce the friction and will not cause oil pipes, etc., to become caked and clogged, and thus interfere with the oil supply.

The writer has on several occasions enabled heavy machinery to remain in service by the use of graphite as described above, where a forced shutdown would have been necessary without its use. On occasions where an oil of the proper viscosity is not available, it is frequently possible to use a thinner oil after adding about 0.5 per cent of deflocculated graphite, as explained above. The reduction of starting torque required by reducing the friction not only results in better voltage regulation of the circuit when motors are started, but tends to keep down the peak load. H. G. GERGENS.

Chicago, Ill.

Removing Vapors from Pulp Mill Grinder Room

THE grinder room of a pulp mill which contained ten, three-pocket grinders, mounted two in line and connected to 1,400-hp. motors, was originally equipped with four exhaust fans, each driven by a 1-hp. motor to remove the vapors formed by the contact of the wood on the grindstones. Owing to the low ceiling of the room, these vapors were hard to remove, the result being that they condensed on the ceiling and crane rails and made the room a sloppy place to work in. Furthermore, the 1-hp. motors driving the fans burned out from time to time, and no amount of maintenance could prevent it.

A 24-in. stack was then built, as shown in the illustration, to get rid of some of the vapor by natural draft, but this also proved a failure. The plant had an old induced draft fan that was originally used in the boiler house and which had been replaced when the power plant was enlarged. This fan was installed as shown, connected in the 24-in. stack and belted to a 25-hp., 1,800-r.p.m. induction motor which was also a spare. It has given such good service that the four original exhaust fans have been dispensed with, and the ceiling is perfectly dry at all times.

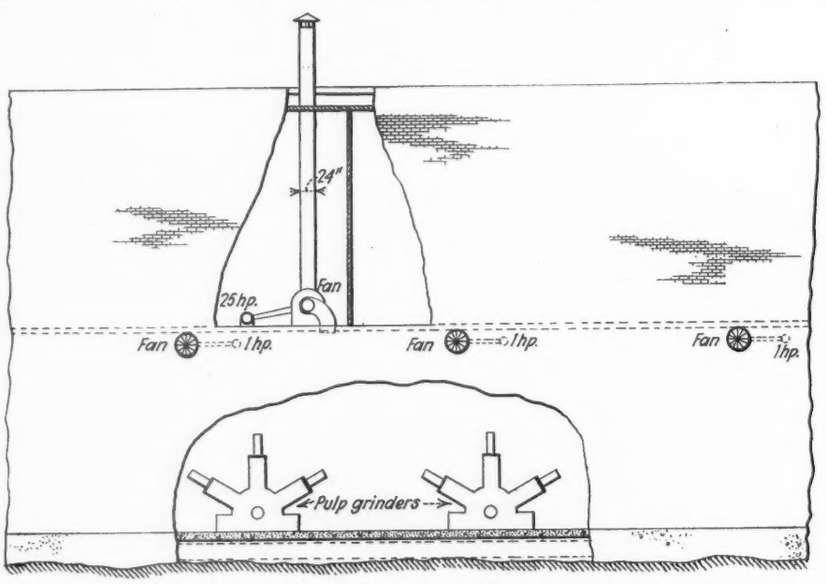
Nothing had to be purchased, and the installation was made by the plant mechanics. Even the wiring of the motor cost nothing, aside from labor, as a spare line passed within a foot or so of the motor.

Two of the original fans and their motors are being used on other applications and two spare units, which may come in handy at some future time, are available.

The increase in power consumption, 25 hp. against 4 hp., has proved an actual saving against the former necessary repairs, with the elimination of the vapors thrown in for good measure.

H. E. STAFFORD.

Port Arthur, Ont., Canada.



Arrangement of 1-hp. fans, and 25-hp. unit that replaced them, for removing steam from the grinder room of a pulp mill.

Determining Resistance and Temperature Rise of Heavy Conductors

RATING of many electrical devices is largely determined by the maximum temperatures permissible, and is usually stated in terms of temperature rise above the surrounding air. The thermometer method of determining the temperature is convenient for some equipment, but not proper for others. Many laboratories have accurate volt- and ammeters for determining the

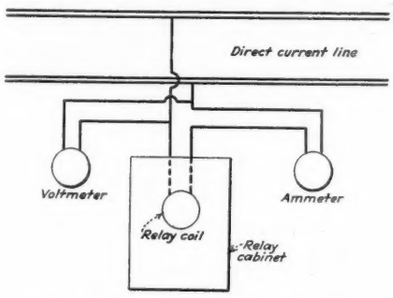


Fig. 1—Connections for determining resistance of relay coil.

temperature rise of a conductor by the resistance method, which may show a 5 to 20 deg. rise above that of the thermometer method, and may often be used to advantage. Neither method shows "hot spot" temperatures, although this is not necessary except in highly-specialized work.

In Fig. 1 is illustrated the proper connections for determining the actual resistance of the coil in an inclosed voltage relay *X*, where the introduction of a thermometer would require that the door be kept partly open, or that the normal air circulation be disturbed in other ways. Suppose the first instrument readings with the coil at room temperature were 116 volts and 0.37 amp. By Ohm's law this coil has a resistance of 314 ohms at this temperature. One hour later the readings may be 114 volts and 0.30 amp., corresponding to 380 ohms. Other readings may be taken at fifteen-minute intervals until no further resistance increase is noted. If the maximum readings indicated 116 volts and 0.28 amp., a final resistance of 414 ohms would be determined.

The rise in resistance has been 100 ohms from a starting point of 314 ohms, or a 32 per cent rise. Each 10 per cent increase in resistance of annealed copper represents a rise of approximately 25 deg. C. or 45 deg. F.; therefore 3.2 x 25 = 80 deg. C. rise, or 3.2 x 45 = 144 deg. F. rise.

In this particular case, and in any other case where the first and final ammeter readings are taken at identical voltages, the voltmeter readings may be ignored and only the amperes used, as follows: 0.37 ÷ 0.28 = 1.32, or 132 per cent, which is an increase of 32 per cent from the starting resistance, which checks with the resistance method above.

This latter method of using only the amperes applies when it is known that the voltages are identical at each reading. It is not probable that the voltages can be kept constant throughout the entire test, but there should be intervals where simultaneous readings of both instruments may be obtained with the voltmeter reading unchanged.

Temperatures of alternating-current coils may be similarly calculated by taking the instrument readings quickly with direct current and then switching to normal alternating-current operation for the heating period; then make a final resistance test with direct current. Any such use of direct current through an alternating-current coil must be at a much lower voltage than that of the alternating-current rating.

After obtaining an understanding of the above procedure, it is but one step to the development of a useful method of determining the temperature rise of heavy conductors, whether they are busbars, underground cables, series field coils or an edgewise-wound series relay coil, such as is illustrated with the proper instrument connections in Fig. 2. For this work only two instruments are needed: an ammeter with a suitable shunt and an ammeter movement without its shunt. The latter is a milli-voltmeter except for the scale, which may be calibrated in amperes for use with its shunt, which is not em-

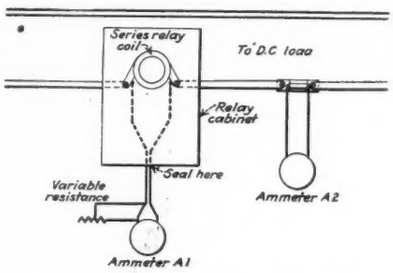


Fig. 2—Method of determining temperature rise in series relay coil, or heavy conductor.

ployed here. In this way the calibrated scale has no value except as a basis for calculations in proportion, as explained later.

As shown by the illustration, the conductor to be tested constitutes the shunt for the milli-voltmeter *A1*. Ammeter *A2* is for the purpose of enabling the operator to read *A1* only when *A2* is at some assumed standard amperage for which current the heating of the series coil is being tested. The variable resistance in series with *A1* is for adjusting it to read near the center, or slightly above the center of its scale, at the beginning of the test. This will give accurate results without the probability of reaching the end of the scale at a maximum temperature of the conductor under test.

It is not necessary to use the standard shunt leads to instrument *A1*, but no soldered or bolted joints should be included in the section of the heavy conductor being tested. The instrument leads should not be fastened under any bolt in common with other line wires; a separate soldered or bolted joint as shown in Fig. 2 should be used.

The first step is to connect the instruments properly, adjust the line current to the required amperes, according to *A2* and then adjust the resistance so that *A1* will show a reading at about half scale. Record these values as accurately as possible and *do not move* the adjustable resistance after these readings have been taken.

Suppose the pointer on *A1* rises from an initial reading of 60 to a final reading of 90 with no change in the true amperes as shown by *A2;* then there has been an increase of 50 per cent in the resistance of the heavy coil under test. This represents a rise of 125 deg. C., or 225 deg. F., which may be expressed in actual temperatures by adding this temperature rise to that of the surrounding air at the beginning of the test.

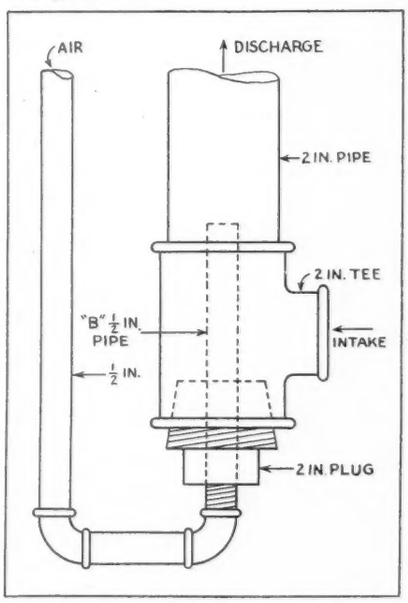
There are many applications of the electrical method of determining temperature rise, which are limited only by the ingenuity of the operator.

Research Department, Kohler Company, Kohler, Wis. EARL R. WITZEL.

Drainage Siphon Made from Pipe Fittings

A short time ago we were obliged to drain a concrete pit containing about four feet of water, and having no pump on hand we rigged up a siphon as shown in the sketch. The only special work required was tapping out the 2-in. plug *A* and running down the threads on a piece of ½-in. pipe *B*, so that it would extend out of the bottom of the plug to take an elbow. Compressed air at a pressure of 100 lb. was used and we soon had the pit drained.

Chief Electrician, Cold Spring, Minn. CHAS. A. PETERSON.

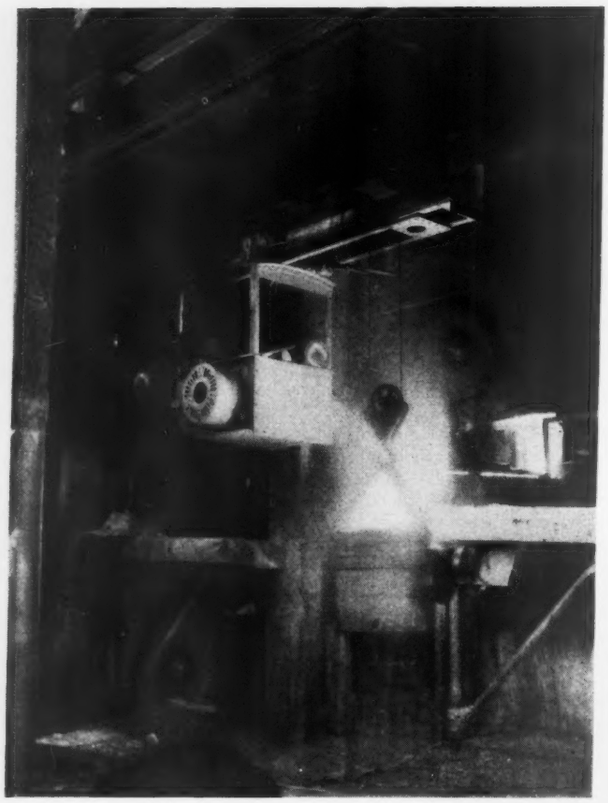


Details of siphon made to drain a pit instead of employing a pump for the purpose.

How We Are Organized to Service

HOIST CABLES

By WM. E. RASMUSSEN
Chief Electrician
The Studebaker Corporation
South Bend, Indiana



One application of cable that is far from ideal. Careful inspection must be of the first order when handling molten metal.

After a test lift was made this machine tool was lowered to the loading dock below.

FOR the same reason that chain is only as strong as its weakest link so is hoist cable such as is used for cranes, elevators and so on, only as strong as its weakest strand. As a medium for handling material cable is most commonly used and the most difficult to service, but if the same degree of intelligence is used in its application, and the same or greater precautions are taken to prevent misuse little or no difficulty will ever be experienced in obtaining the service built into it. These conditions, however, are predicated by the fact that the cable must, first of all, be of good quality.

At the South Bend works of the Studebaker Corporation where the manufacture of all products is now centralized there are 35 cab-controlled cranes, and almost 100 electric hoists of different types varying in capacity from ¼ to 3 tons. The maximum capacity of the cab-controlled cranes is limited to 10 tons, however, the majority are rated at 5 tons.

Not only is the electrical department responsible for the electrical equipment of the cranes, but also it does all of the mechanical repair work on them that is required. Freight and passenger elevators also come under the supervision of this department to the same extent as do the cranes and other hoist equipment. The principal reason for this concentration of supervision is to insure the attention of specialists assigned to service them. To this is attributed the success in operating them, for rarely has a cable broken or failed in normal service. When a failure occurs it is usually the result of abnormal conditions of operation such as hooking onto a furnace weighing 15 tons or more with a 5-ton crane.

Every crane operator is included in the electrical department as a member thereof. A crane foreman

in the department decides whether a crane is fit for service, and if not what repairs are needed to put it into such condition that it is safe not only for the operator but production employees working beneath it, and of equal importance, that production will not be jeopardized. The operators are required to oil and grease their equipments at certain intervals, which are also utilized in locating mechanical and electrical faults that are reported to the foreman, who as stated, gives approval for its continuance in service.

Floor-operated cranes are maintained by repairmen who have been assigned to the departments by the electrician in charge at that plant. Because of the activity of these hoists spare cables are always kept on hand to minimize the period of shutdown occasioned by their failure.

On all floor-operated cranes or hoists the department or section maintenance man assists in the inspection, and in fact every employee in the electrical maintenance department is capable of making a thorough inspection. There are two crane inspectors who devote their time to this work only. Their busiest period comes on idle days and week ends when the work could not be done otherwise. Elevators are excepted here as it is possible to inspect them daily rather than permit them to operate during the longer period established for them by law. The system of inspection is similar to that for cranes and hoists, except that the inspector oils and greases the equipment.

Floor - operated cranes for which spare cable is always kept on hand to minimize interruptions to production.

The results of these inspections are tabulated on a form, which is reproduced herein, as fast as inspections are accomplished they are recorded. Blank spaces opposite cranes and their location indicate the absence of inspection. This chart is checked weekly to prevent a crane from continuing in service without attention.

Of all the equipment on the crane, hoist, or elevator no one element is scanned as carefully as the cable. With elevators, if the cable begins to deteriorate it is changed immediately instead of waiting for the insurance inspector to condemn it. The crane inspectors make up all cable that is to be used. Complete details for the procurement of this cable are to be found on the crane inspection report. The requisition for material is made out in the electrical department on stores to furnish material which is directly charged to the department in which the crane is located.

Light load is no excuse for lack of inspection. Failure of the cable would probable result in costly damage to product and tie up operations.

All crane cable used must first have the approval of the electrical maintenance department, which decides by lot or specification whether it is suitable for use in the various locations. Previous to becoming a stock item samples are forwarded to the Methods and Standards Laboratory where they are given exhaustive tests. This method insures getting plow steel if plow steel is specified regardless of the statements to the contrary. It makes little difference by whom the cable is made if it meets the specifications that have been approved by the department.

Where a cable does not stand up in the manner it was intended to, the problem is referred to cable experts to solve.

Inspection of cables is and perhaps always will be done visually and beyond that a certain amount of experience is needed in making conclusions as to the fitness of a cable to remain in service under certain conditions. Outside of wear occasioned by constant use and its subjection to heat and other influences, failure of strands is used to a great extent in judging the necessity for replacement. Our practice in this respect is to discard any cable if three wires in the same strand are found broken in a distance of 12 inches. When a cable is found in this condition it is changed as soon as possible and at the latest, within the week. Spliced cable is not used and if cable that is removed from service is not sent to scrap it is salvaged in about 10-ft. lengths for shorter lifts.

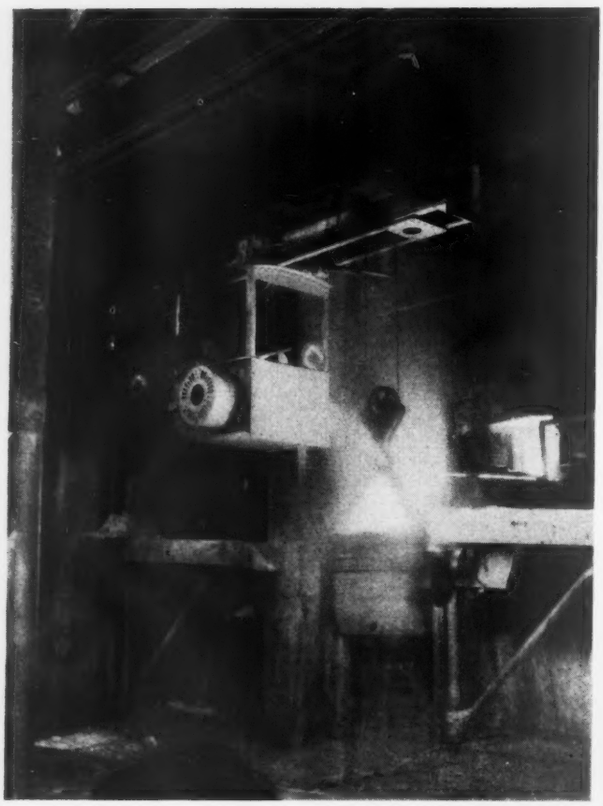
Because of the reliance that must

How We Are Organized to Service

HOIST CABLES

By WM. E. RASMUSSEN

Chief Electrician
The Studebaker Corporation
South Bend, Indiana



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CRANE INSPECTION REPORT

CRANE NUMBER	MAKE OF CRANE AND CAPACITY	LOCATION OF CRANE	SIZE, GRADE AND CONSTRUCTION OF CABLE	LENGTH OF CABLE	WEEK ENDING					WEEK ENDING					WEEK ENDING					WEEK ENDING				
					DATE OF INSPECT.	LIMIT SWITCH INSPCT.	CONDITION OF CABLE	DATE CABLE CHANGED	INSPECT. BY	DATE OF INSPECT.	LIMIT SWITCH INSPCT.	CONDITION OF CABLE	DATE CABLE CHANGED	INSPECT. BY	DATE OF INSPECT.	LIMIT SWITCH INSPCT.	CONDITION OF CABLE	DATE CABLE CHANGED	INSPECT. BY	DATE OF INSPECT.	LIMIT SWITCH INSPCT.	CONDITION OF CABLE	DATE CABLE CHANGED	INSPECT. BY
1	SMR 5 TON	FOUNDRY	1-2" 6X37 MONARCH																					
2	SMR 5 TON	FOUNDRY	1-2" 6X37 MONARCH																					
3	SMR 5 TON	FOUNDRY	1-2" 6X37 MONARCH																					
4	SMR 5 TON	FOUNDRY	1-2" 6X37 MONARCH																					
5	SM																							
6	SM																							
7	SM																							
8	SHA																							
9	SHA																							
10	SHA																							
11	SH																							

ROPE RECOMMENDED FOR STUDEBAKER CORP. SOUTH BEND WORKS
ELEVATORS

Old Elevator Plant #1	3/4"	8x19G Special Traction Elevator Cable
Haughton Elevator	5/8 & 3/4"	8x19G Special Traction Elevator Cable
N. & S. Pass Elevators Adm. Bldg.	5/8"	8x19G Special Traction Elevator Cable
Elevator Governors	1/2"	8x19E Swedes Iron
Elevator Hand Lines	3/8 & 1/2"	8x19E Swedes Iron

ELEVATOR GATE MACHINES

Building #84	Gate operating rope - 3/8"	8 x 19E C.C.S.
	Gate counterweight rope 1/2"	8x19E C.C.S.
Foundry	Gate operating rope 7/16"	8x19E C.C.S.
	Gate counterweight 1/2"	8x19E C.C.S.

Engineering Dept. 1-1928

Crane inspection report which covers a four-week period. The sheets are ordinary blue prints made from a standard tracing. *(Below)* Specification sheets of cables recommended for particular applications. These specifications must be approved by the electrical maintenance department.

be put on cables every precaution is taken to safeguard them against damage. Side pulls in sliding material on balconies was a frequent cause of burning off the cables as they were snagged against the crane conductors, which were installed below the crane. This trouble has been entirely eliminated by installing these conductors overhead, that is, above the level of the bridge girders.

Another practice that is recommended for others to adopt is the taking of a test lift with a heavy object. A view is shown in moving a heavy machine tool from an upper floor to the loading dock below. The test lift revealed that brakes needed servicing, the adjustment of which enabled the equipment to be lowered with complete safety.

Testing Steel Sheet for Weldability

ONE of the fundamental considerations for successful oxy-acetylene welding of steel sheet is the careful selection of good material.

Chemical composition alone is not sufficient indication of the quality of steel sheet. Welding qualities are determined to a great extent by the presence or absence of minute amounts of impurities in the steel. It is always advisable, therefore, to specify that the steel shall be suitable for welding and as a further check to test lots of steel as they are received from the mill. Such a test is easily made in the following manner:

Select a piece of sheet from the lot, about 6-in. square and place it flat on the welding table. Fit a welding tip to the blowpipe, one size smaller than that prescribed for work on your welding chart. Light the blowpipe and adjust the flame to neutral. Hold the blowpipe so that the tip of the inner cone of the flame is about ⅛ in. away from the sheet. Move the flame slowly along a straight line so that the sheet will be melted without burning clear through. After a strip about 3 in. long has been melted in this way, hold the blowpipe still until a hole is burned through the sheet.

If the sheet is high grade the path followed by the blowpipe will be free from an excess of oxide or scale. Also it will be regular and smooth on the upper side. The under side of the test sheet will show a slight sag of smooth metal, free from oxide.

Sheet of inferior quality will show an oxide deposit on the upper side, part of which will be porous or flaky scale. There will also be a succession of irregular ripples, higher in the center than on the edges. The under side will show a sag that is covered with oxide. There may even be a series of small holes blown through by the sparking action of the impurities. In poor sheet the metal will be burned through very soon after the blowpipe is held stationary, in much less time than is necessary to put a hole in good sheet. The hole, incidentally, will be irregular with rather ragged edges. When the test sheet cools examination will disclose porous, spongy looking globules of oxide on the edges of the holes.

This simple test, which can be quickly made on average samples selected from each lot of steel, provides assurance that the sheet is of the proper quality to make a high-grade product.

Some pointers on

Testing Watt-hour Meters

By NICHOLAS COOK

Electric Meter Dept.
Public Service Electric and Gas Company
Paterson, New Jersey

TO THE average factory electrician a watthour meter is more or less a thing of mystery, yet at times he would find a knowledge of its principles highly useful. He may be called upon to determine whether or not his watthour meters are accurate, and indeed he should check the accuracy at regular intervals if the utmost usefulness of the meters is to be attained.

An ordinary voltmeter, ammeter, or wattmeter placed on the line merely indicates the instantaneous voltage, current, or load. A watthour meter does more: it sums up, or *integrates,* the instantaneous values and displays the total by means of one or more dials.

Such a mechanism requires a rotating element and for this reason all present-day watthour meters or amperehour meters are essentially electric motors. Direct-current meters are of the commutator or mercury type; alternating current meters are simply small induction motors.

In these meters the speed of the rotating element is proportional to the load carried by the meter. Each revolution represents a certain number of watthours, or ampere hours, depending upon the rating and type of the meter. Therefore, to test the accuracy of the meter it is necessary to determine whether the speed of the disk is correct for the load applied.

The number of watthours recorded by each revolution of the disk of a watthour meter is called the *watthour constant,* and this is the fundamental constant in all meter calculations. This number is usually stamped upon the disk or upon some other part of the meter. American manufacturers have not yet standardized a full-load speed; and since the watthour constant depends upon the full-load speed, it follows that there is no uniformity in constants of meters of the same rating but of different manufacture or type. For example, following are watthour constants of four different induction meters rated at 5 amp., 110 volts:— 0.6, $\frac{1}{3}$, 0.3, $\frac{5}{24}$.

Where instrument transformers are used the meter commonly has a five-ampere rating, the output of the transformer secondaries at full load being five amperes. The ratio of transformation is generally expressed as n ÷ 1. In this case the normal watthour constant of the five-ampere meter must be multiplied by *n*. For example, with 200-amp. transformers the ratio is 40 to 1, and the 5-amp. constant must be multiplied by 40. On primary (high potential) metering installations where both current and potential transformers are used, the 5-amp. constant must be multiplied by the product of both ratios.

In this way, using the 5-amp. constant as a base, the watthour constant of any size of meter can be computed.

On large meters the gear mechanism, or register, records a fractional part of the total energy and the dial reading must then be multiplied by the *dial constant* which may be 10 or 100 or some other number according to conditions. This constant is not used in checking the accuracy but only in reading the "index" on the dial.

There is another constant with which under normal conditions the maintenance man is not directly concerned; namely, the *register ratio.* Since all meters of a given type have the same full-load speed, regardless of rating, the gear mechanism must be arranged to record the energy correctly. The register ratio may be expressed as the number of turns made by the gear engaging with the shaft to one turn of the fastest moving dial pointer, and it varies inversely as the rating of the meter. In case of error a register ratio too small will make the dial reading too high. The ratio is generally stamped upon the inside plate of the register.

Testing—The maintenance engineer does not usually have rotating standards at his disposal, so he must rely on his indicating instruments.

The method is simple. A given number of disk revolutions are timed by means of a stop watch, or even with an ordinary watch in the hands of an assistant. The watthour constant being known, the total watthours can be computed. This total is compared with the average watthours determined from the readings of a wattmeter, or of voltmeters and ammeters if the power factor is known.

Example 1—Check the accuracy of a type I-14, 50-amp., 110-volts, G.E. meter.

Data: Watthour constant = 3.
Observed revolutions = 50.
Observed Time = 2 min. 6 sec. or 126/3600 hr.
Average Load = 40 amp. at 110 volts (unity p.f.).
Average Watts = 4,400.
Meter watthours = 50x3 or 150.
True (indicated) watthours = 4,400x126 ÷ 3,600 = 154.
Accuracy = 150 ÷ 154 = 97.4 per cent.

The meter is 2.6 per cent slow according to this test.

Example 2—Check the accuracy of a type D-7, 5-amp., 220-volt, two-phase, G.E. meter with 400-amp. current transformers.

Data: Watthour constant of 5-amp. meter = 1.2.
Transformer ratio = 40/1.
True watthour constant = 96.
Observed revolutions = 40.
Observed time = 89 sec.
Average watts load = 15,400.
Meter watthours = 40x96 or 3,840.
True watthours = 15,400x89 ÷ 3,600 = 3,810.
Accuracy = 3,840 ÷ 3,810 = 100.8 per cent.

This meter is 0.8 per cent fast according to this test. In all testing of this nature, extreme care must be used, and the final result should be the mean of several tests.

Storing and Distributing Naphtha—*Safely*

By ROBERT A. ALTHAUS

Mechanical Engineer
Deere & Company
Moline, Ill.

THE handling of naphtha, gasoline, or oil in large or small quantities is always accompanied by an element of risk, especially in an industrial plant where a fire from such causes is apt to result in a considerable loss of life and property.

When such materials are purchased in small quantities, they are generally delivered in drums, which are liable to leak, and the danger of spilling while draining drums is ever present. The storing and delivering of this material to various parts of a plant at times offers a great fire hazard, in addition to the difficulties experienced in handling these drums.

As a means of increasing the safety of handling and storing of naphtha, a system was recently installed with the object of embodying as many practical safety features as possible, which would facilitate ease in handling the naphtha and at the same time reduce the danger of fire or explosion to a minimum.

By making purchases of naphtha in carload lots, a saving ranging from 15 to 20 per cent, and even greater at times, is realized as compared with the previous method of drum lot purchases.

The selection of the storage tank was done with particular care in order to eliminate the possibility of leaks, which would be great in a light weight and poorly fabricated tank. Certain facts and requirements concerning the safety of such a tank installation were also given special attention, and as reliable specifications for such an installation were not locally readily available, they were obtained from a fire underwriter company.

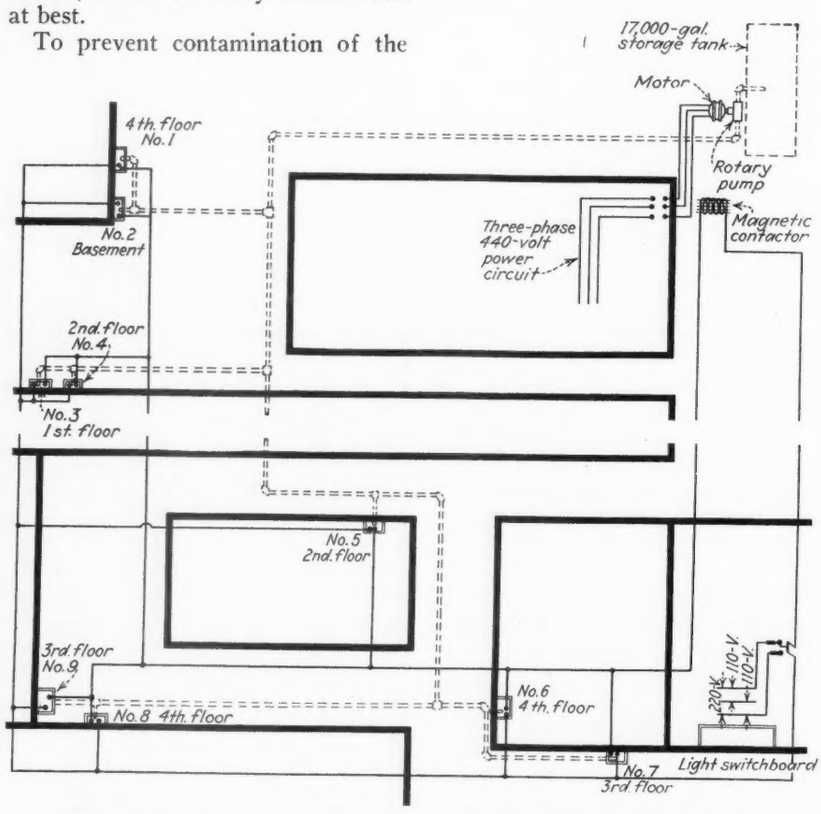
Before installing the steel tank, it was given a coat of black asphaltum paint, and allowed to dry. Then the tank was carefully slung and lowered into the hole by a railroad wrecking crane, the cost of the work and crew being $150.

After the tank was set in place, 6 in. of sand was packed around the tank to protect it from ashes in the ground, as steel, it is claimed, disintegrates fast when buried in a bed of ashes.

The preparation of the hole in the ground for the tank and the actual installing of the tank was done with the utmost care. Otherwise, even the best of tanks are apt to leak after being buried; and the problem of repairing a leaky tank, especially when buried, is an extremely difficult one at best.

To prevent contamination of the naphtha in the tank, all pipes and connections to the top of the tank—connections rarely being made to the bottom of such a tank—were made absolutely tight, and the piping was run in a manner that will eliminate excessive strain on the tank connections due to any settling of the tank or ground where the pipes are run. The upper end of the fill pipe was so located and capped that no water can drain or seep into the pipe either when the cap is being taken off or when covered.

A special connection fitted with a fine mesh copper screen was employed for the top of the vent pipe.



Layout of system for storing and distributing naphtha. Each of the outlets indicated by the Nos. 1 to 9 is fitted with a meter and a self-closing valve equipped with a 220-volt switch.

This pipe fitting not only prevents the entrance of water and dirt, but eliminates the danger of explosion of the contents of the tank due to the possible ignition of escaping gases. As an added precaution, the end of this vent pipe was located several feet from the ground and away from window and door openings; a location which protects the pipe from possible injury was, of course, selected. The bottom of the sump suction is located about 1¼ in. from the bottom of the lower end of the tank; a slight pitch to the bottom of the lower end of the tank being of advantage in draining water and sludge from the other end of the tank where the suction pipe is located about 3 in. off the bottom of the tank.

The naphtha, in this case, is forced by means of a motor-driven rotary pump to nine points widely separated in the plant, the furthermost outlet being 600 ft. from the storage tank. The steel pump house is located directly adjacent to the storage tank, and near the tank car siding.

The rotary pump forces the naphtha through nine outlets. These various outlets, which are located at elevations ranging from the basement to the fourth floor, are supplied from one main supply line that is tapped.

Each outlet is inclosed in a housing made of copper, and its door, which is made of sheet steel, slides vertically upwards through guides. The weight of the door is counterbalanced by a weight that is attached to it by means of a fusible link.

When an authorized employee needs naphtha, the weighted lever on one of the outlet valves is unlocked, and when the container to be filled is in place, the weighted lever is raised. The raising of this lever, in addition to opening the valve, closes an electric switch. When this switch, which is connected to a 220-volt circuit, is closed, a magnetic contactor is energized. The operation of this contactor starts the three-phase, 440-volt, squirrel-cage pump motor.

The pump continues to operate and the naphtha, which is metered at each outlet, continues to run until the valve lever is released, the weighted end of the lever causing the valve to close and remain closed except while being held open. After the lever is returned to the closed position, the 220-volt circuit is again opened and the pump motor is caused to stop. So with this method of control the pump pressure on the system is eliminated, except when a supply of naphtha is needed at any of the outlets.

Try Putting Your Job on Paper

(Discussion)

THE editorial, "Try Putting Your Job on Paper," in the April number of *Industrial Engineering*, takes up an important procedure. I have practiced putting the other fellow's duties on paper for several years as a means of developing workmen. Here is a sample of these instructions:

INSTRUCTIONS FOR MOTOR INSPECTORS

The main thing today is production, which cannot be maintained unless the wheels are kept turning. We, the electrical department, are held responsible for the operation of the motors. We do not want any lost production charged against our motors. These rules are only suggestions to guide you in the work and are not complete.

Inspect all motors daily and oil when needed. Blow out all motors with the compressed air hose every Sunday. Be careful to have the air dry before directing it onto the winding. Do not hold the hands in front of the air nozzle while waiting for it to dry. There may be pipe scale and dirt in the air that will cause an injury; we have already had this experience. Wipe off all dirt, dust, stock, grease, and oil from the motors and starting equipment every Sunday.

Through the week, wipe off any stock, grease, oil, etc., found on any motors or starting equipment that is extra bad, if it can be shut down for cleaning without any lost production. Do not attempt to do any wiping or cleaning on a motor while it is running; the risk of getting hurt is too great. When cleaning the heating fan motors that are kept running on Sunday shut them down, and start them up again when through.

Be careful not to over-oil any motor bearings. When a bearing needs oiling, pour in a little oil at a time until it rises to the proper level in the oil gage. Oil will leak out of some bearings if carried level with the top of oil gage. Oil in any bearing will seek a level and it cannot be kept any higher.

Any time that you are afraid the oil level is too low look at the oil rings and if they pick up oil freely it is high enough in the gage. When you are making a study of a motor to determine the proper oil level, visit it several times during the day to guard against the possibility of its getting low enough to burn out the bearing.

Oil should never be poured into a bearing until it is level with the top of oil gage while the motor is running, for the reason that the oil rings dip into the oil and keep in suspension a certain amount that will settle back into the oil reservoir and over-flow to the motor base and floor every time the motor is stopped.

Report any motors that are found with an excessive amount of vibration; also report any motors that need oiling frequently. Make all reports and suggestions in the form of written notes. This will insure better attention.

Clean up any oil spots found on the floor, caused by the motor. Note the bearing temperatures and when any are found hotter than the usual run, first look to see if the oil rings are turning. If the rings are turning and the oil level is o.k., it will be necessary to slack off the belt sufficient to cool the bearing.

When making motor inspections, see that no belts are running loose enough to slip and interfere with production. On the other hand, see that no belts are drawn up tight enough to overheat the bearings. When a small motor bearing burns out, if possible get the end belt off immediately, before the bearing gets a chance to cool and seize the shaft.

When a belt is tightened, watch the motor bearings very carefully for the first half hour to see that they do not heat up. When a new motor is put in place, see that the oil rings are in place and turning.

When a new rubber belt is put into service, it should be treated with belt dressing for the first few days, to make it pliable enough to prevent slippage and to keep from having to run it with too great tension. When using belt dressing, use it sparingly. Do not put too much on or spill it on the floor. Report immediately any belts that are found badly worn or with loose plies.

Report any motors or starting equipment found with broken or disconnected ground wires. Also report any bare wires or badly insulated joints.

When a motor is disconnected for removal, first draw the oil out of the bearings to prevent spilling it on the winding and floor. Return any used oil to the oil house to be filtered and used in bearings of less importance.

Report any motors found needing covers.

Report any electrical equipment found with water dripping on it.

Report any switches or starting equipment found very rusty and needing painting.

Report any brushes sparking or badly worn.

When cleaning look for defects in the equipment.

Do not clean near any live parts of equipment.

Do not use any air hose with a metal nozzle near any live bus work.

Report any motors found with the pulleys overlapping the bearing, making it difficult to see the oil gage or to get at the oil-well cover.

Report any motors found operating at a high temperature.

Sometimes a relay plunger will work loose and change the setting. When a relay is giving trouble and tripping out the starter, check it to see if it needs oil. Also check the ampere setting as follows, allowing for a 25 per cent overload: Assume the motor to have a full load current of 100 amp., then the relay should be set for 125 amperes.

Study these rules carefully and often enough so that you will remember them while making your inspections. If you have any suggestions to make these rules more complete, they will be appreciated.

MARIN PHILLIPS

Electric Superintendent
International Paper Company
Niagara Falls, N. Y.

· QUESTIONS ·

Asked and Answered by READERS

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Trouble with Commutator of Motor-Generator Set

We have been troubled for some time with the commutator of a motor-generator unit used for street railway power, wearing faster under the outer brushes than elsewhere. Likewise, this portion of the commutator will not take on the fine gloss that the remainder of the surface shows. These conditions are found only under the outermost brush on each brush stud. I have carefully checked the brush position, spacing, spring tension, and have even used a brush of different grade, without results. When the trouble first developed the outer brushes would become hot enough to discolor the brush shunts, but they now run comparatively cool. I might say that this d.c. armature was completely rewound about a year prior to the time that this trouble developed. It will be much appreciated if some reader will explain the cause of the trouble and tell me how to overcome it. S. F. H.

Ottawa, Ontario, Canada.

Reducing Head on Centrifugal Pump

WILL someone tell me how a reduction in the head against which a centrifugal pump is working affects the horsepower requirements? Specifically, I should like to know whether a pump that has been delivering 250 g.p.m. at 100-ft. head can be used when the head is reduced to about 60 ft. The pump is direct-connected to a 1,750-r.p.m. induction motor and I have been told that the motor will be badly overloaded. Is that true? What changes in the pump will be necessary to insure safe operation at the new head, with the rate of discharge remaining about the same? W. J. S.

St. Louis, Mo.

Are Lightning Arresters Needed Here?

The question of lightning protection has come up in connection with some changes in our power supply. Current at 6,600 volts will be supplied from an overhead line about 1,200 ft. long to a bank of three 500-kva. transformers in our substation, where it will be stepped down to 2,300 volts. Part of the supply will be distributed at 2,300 volts by an overhead line to a building about 900 ft. distant. Another bank of transformers in the substation will step the remainder of the 2,300-volt supply down to 440 volts, which will be carried through underground cables to four other buildings. The longest cable run will be about 500 ft. Should lightning arresters be placed on any of these lines? If so, which ones? Without arresters would there be any danger of lightning causing trouble with our underground cables? J. O. P.

Philadelphia, Pa.

Bearings for Different Lineshaft Speeds

Several times a question has come up regarding the proper type of bearing to use for various lineshaft speeds. For speeds below 50 r.p.m. we usually use a good babbitted bearing, grooved, and lubricated with grease, which is fed either by a compression cup or the pressure system. For speeds above 50 r.p.m., and up to about 125 r.p.m., the ring, chain, or collar-oiling bearing is used, and from 125 to 350 r.p.m. a wooden-block, capillary-oiling, babbitted bearing is employed. Above 350 r.p.m. we use anti-friction bearings, either of the ball or one of the roller types. I shall be glad to see some discussion on this subject. In particular, I should like to know if our practice, as outlined here, corresponds in general with that of other readers.

Birmingham, Ala. S. J. M.

Removing Deposits from Transformer Cooling Coils

For some time we have experienced trouble in keeping the temperature of several large, water-cooled, oil-insulated transformers down to normal, with normal load. Recently it was found that the water coils and pipe connections are heavily coated on the inside with what I presume is lime mixed with rust. Doubtless, this deposit acts as a heat insulator to slow down the transfer of heat to the cooling water, and also restricts the flow of water. I wish that readers would tell the best method of removing the deposit from the coils of these transformers without injuring them. L. T. W.

Detroit, Mich.

Soldering Splices in Wires

I have not as yet found a really good method of soldering splices in wires not over No. 8 in size. So far I have always used a gasoline blowtorch, and sometimes I use an iron with the torch, but it is a slow process. Can readers tell me of any better method of soldering wires ranging in size from No. 14 to No. 8? I. H.

Hurlock, Md.

Effect of Low Voltage on Synchronous Motor

Increasing load in our plant has resulted in lowering the voltage on our supply lines, so that a 200-hp., 2,300-volt synchronous motor frequently has to operate at 2,100 volts, or less. This condition will be remedied later on, but in the meantime I should like to know what effect the lower voltage will have on the motor. It is important that our equipment be driven at a certain speed, but when the voltage drops, the speed seems to go down also. Is that possible? Is the motor likely to be injured? What effect will the low voltage have on our power factor? Tests made some time ago, when the voltage was normal, showed that the motor is loaded to somewhat more than 90 per cent of capacity. Plant conditions have changed very little, if any, since then. J. L. Q.

Kansas City, Mo.

Exterminating Spiders and Hornets

Spiders and hornets, or mud wasps, cause us a great deal of trouble in our power house. The walls and ceilings are painted white, but I do not know whether this color is particularly attractive to these insects. I wish that readers would tell me the most effective method of getting rid of them, as they are very annoying to the men. Also, the matter of cleaning the windows has proved to be expensive and I shall appreciate any suggestions you can give me on the best way of doing this work. G. A. I.

Campbellford, Ontario, Canada.

ANSWERS *to* QUESTIONS

Preventing Radio Interference from Pole Changer

Considerable interference with radio reception has been traced to an old Kellogg pole changer that is used with our plant telephone system. If any other readers have experienced this trouble, I wish they would tell me the cause and remedy for it.

Utica, N. Y. G. L. B.

THE radio interference which G. L. B. experiences is due to arcing at the several interrupting contacts. Although it may not be severe enough for a wave to be radiated any great distance, the interference is fed directly into the telephone wires and might be picked up many miles away. As a rule, however, interference will be experienced only at short distances from the station and lines.

I would advise G. L. B., first, to examine the condensers across the output or ringing leads for breakdowns. If they are in good condition I would completely shield the pole changer. The ground for this shield should be separate from the station ground.

If these measures do not cure the trouble it will be necessary to connect one complete filter in each pair of ringing leads. If the ringing battery leads are more than 2 ft. long another filter should be placed in these leads. The pole changer should be completely shielded, including the filters and batteries.

Several good makes of filters are on the market and can be purchased from any radio supply house.

R. A. BROMLEY.

Bromley Electric Company,
Louisa, Ky.

Changing 30-Cycle Motor for 60-Cycle Operation

We have a 30-cycle, three-phase, 440-volt, 1,750-r.p.m., 1-hp. motor that was never used. Recently need arose for a 60-cycle motor of 1-hp. rating and I decided to change the 30-cycle motor for this purpose, keeping the speed the same. There are 48 slots in the stator and as it was connected for two poles, I regrouped the winding for four poles and changed the single-circuit star connection into a two-circuit star. The motor ran satisfactorily, but became warmer than I think it should. Was the change I made correct? If not, how should this 30-cycle motor be changed for 60-cycle operation, keeping the same speed?

New York, N. Y. J. S.

I BELIEVE that J. S.'s difficulty comes from over-chording the coils. With the 30-cycle, 1,750-r.p.m. connection, with 48 slots in the stator, full pitch, or a chord factor of 1, would be slots 1 and 25. However, this chord factor was probably lessened by putting the coil sides a few slots closer together. Inasmuch as chording a coil under full pitch is equivalent to lessening the number of turns of wire in the coil, it is often done.

A coil that is chorded under full pitch for two poles will be greatly over-chorded for four poles. Full pitch for four poles in this motor would be slots 1 and 13. Hence, if a coil now lies in slots 1 and 25 it is obvious that it is so far over chorded that trouble will result. A coil should never be under- or over-chorded more than 50 per cent of full pitch.

If J. S.'s motor heats excessively the only remedy is to rewind it, using the same size of wire, same number of turns, and the same per cent of full pitch employed with the 30-cycle winding. CARL A. WAGNER.

Denver, Colo.

Effect of Starting 500-hp. Motor Across the Line

I should like to know the probable voltage drop, and the effect on our generating equipment caused by starting across the line a 2,300-volt, 500-hp., 60-cycle, three-phase, 600-r.p.m. squirrel-cage induction motor direct-connected to a blower fan. Assume that the load on the generators is (1), 75 per cent and (2) 100 per cent.

Our generating capacity is 20,000 kw. The voltage regulators are quick response, as are the exciters, and the generators have good inherent regulation. If installed, the 500-hp. motor will be located not more than 100 ft. from the generator bus.

Would it be advisable to start this motor by throwing it across the line, under the above circumstances?

Hamilton, Ohio H. B.

IN reply to H. B., a 500-hp., 600-r.p.m. squirrel-cage induction motor of standard type—one that has not been especially designed for low starting current—will draw about 500 per cent of full-load current when started at full voltage. As the full-load current will be approximately 450 kva., the starting current will amount to about 2,250 kva., or 11.2 per cent of the generator rating.

The probable voltage drop at the generator terminals can hardly be determined without knowing the characteristics of the generating equipment. The voltage drop at the terminals of the motor will depend on the size and spacing of the wires supplying it.

Considering the size of the generator —also, that the voltage regulator and exciter are quick response, and that the generator has good inherent regulation—there can be little doubt that this motor could be thrown across the line without causing a troublesome drop in the system voltage, with the generator carrying either 75 or 100 per cent load. With a 100 per cent load, a drop in voltage such as to result in an annoying "dip" in the lights, may result. If the motor is not to be started often when the lights are on, this will not be an important factor.

As for the motor itself, if it is not a new machine, the manufacturer should be consulted to determine whether its windings are braced sufficiently to withstand the stresses resulting from full-voltage starting. If it is being purchased new, the manufacturer should be informed that full-voltage starting is contemplated. The windings of a motor of this size and speed do not ordinarily require an unusual amount of bracing.

If a new motor is to be purchased, it will be best to use one that is especially designed for low starting current, with a correspondingly low starting torque. Such a motor is better adapted to fan and blower service, because the torque required to start a fan is low and advantage can be taken of the lower starting current.

Besides drawing less starting current, such a motor has the advantage of reducing the stresses on the fan at the start. When starting at full voltage with a standard squirrel-cage motor these stresses may be great enough to be serious, if the fan is direct-connected to the motor.

General Engineer, R. P. GUILDFORD.
Westinghouse Electric & Manufacturing Company,
Philadelphia, Pa.

Preventing Escape of Valuable Material from Dust Collectors

We have a problem in the manufacture of mixed feeds that is very troublesome. Some of our product is caught in dust collectors as it comes from the pulverizers or hammer mill, but too large a percentage of it is lost through the ventilators for these collectors. A stocking placed on the ventilator will filter out the fine material for a short time, but as it is exposed to the weather it gradually becomes clogged with dust, particularly on damp or rainy days, and loses its effectiveness. The dust collectors are placed well above the pulverizers, and the ventilators on the dust collectors are about 40 ft. above the pulverizers. Can anyone tell me how to overcome this trouble?

Cayuga, N. Y. J. M. H.

ANSWERING the question by J. M. H., to eliminate completely this item of waste may require expensive apparatus, the cost of which might outweigh the value of the material recovered.

The basis of most equipment of this sort is the "maze" or "labrynth effect" wherein the maximum amount of projecting areas is employed to arrest the

ANSWERS *to* QUESTIONS

fine material without offering too much resistance to the flow of air.

There are many forms of such apparatus on the market, which are very efficient and more or less costly. One of the simplest and most effective consists of a spiral attached to the inside of the collector or cyclone. The material is thrown against this as it sweeps around, and drops as its velocity is arrested. JOHN S. ISDALE.

Plant Engineer,
International Silver Company, Factory K,
Meriden, Conn.

How Can Surge Be Taken Out of Conveyor Chains?

I would like to hear from some of the readers as to what they are doing to take the jump or surge out of their conveyors.

There are five conveyors in the plant I am responsible for and they all surge to a greater or less degree. In the shorter ones this amounts to so little that it does no particular harm, but in the longer ones which are heavily loaded it seems to rock the whole structure and must be putting a heavy strain on it, which will sooner or later cause a failure.

We had motor readings taken and the motors are not overloaded, and the tachometer reading shows no fluctuation in the speed. We have further checked the entire conveyor and the chain is not catching at any point. If anyone has licked this problem I would appreciate knowing how it was done.

Birmingham, Mich. F. G. L.

ANSWERING F. G. L., I suggest that he oil the pins at each link of the chain, and the rollers at the corners. This will greatly reduce the surging.

The only explanation which I have to offer for the condition he mentions is that the surging is caused by the difference between the starting and the running friction (static and kinetic friction). That is, once the tension becomes great enough to overcome the static friction, and the chain starts to move, the motion continues until the tension is reduced far below the starting value. This surging has been known to amount to 4 ft. on chains of great length.

To reduce the surging still further it will be necessary to brace the horizontal and vertical corners much more rigidly than at present, so that as the tension builds up there will be much less "give" to the corners and thus less "come-back" when the chain starts and the tension is relieved.

A simple automatic oiler can be arranged, consisting of two drip-feed oilers dripping onto a piece of flat lamp wick, such as was used in the old-time oil lamp. The wick should be applied to the top edge of the chain by means of long, flat strips of thin phospher-bronze spring, spring brass, or a piece of flat clock spring

ROBERT W. DRAKE.

Consulting Engineer,
McCormick Works, International Harvester Company,
Chicago, Ill.

Limiting Factors for Crossed-Belt Drives

Rearrangements planned for some of our departments will necessitate the use of a number of crossed-belt drives. These belts range from 3 in. to 10 in. in width and according to present plans will have to run on center distances varying from 10 ft. for the smaller belts to a maximum of 23 ft. for the larger ones. I want to avoid trouble with these drives and wish some reader would give me formulas or limits that I can safely use for (1) maximum width of belt that can be crossed, (2) minimum and maximum center distances and (3) maximum pulley ratios.

Brooklyn, N. Y. J. C. O.

REFERRING to the question asked by J. C. O. in a recent issue of INDUSTRIAL ENGINEERING, there is no rule or formula, so far as I know, that is perfectly satisfactory for crossed-belt drives because of the many factors involved. Results are dependent on which pulley is the driver, the smaller or larger. Results are also dependent on the pulley sizes; position of tight side; pulley ratio; distance between shaft centers; width of belt; and type of belt. Type of belt is very difficult to put into a formula.

However, the following formula is safe for most conditions and is applicable for high-grade, high-friction, double leather belts up to 6 in. in width:

$$C = 6 + \left(\frac{D + d}{10}\right)$$

where D = diameter of driving pulley in inches.
d = diameter of driven pulley in inches.
C = minimum center distance in feet.

For belts wider than 6 in. use this formula:

$$C = \frac{W}{6}\left[6 + \frac{(D + d)}{10}\right]$$

where W = width of belt in inches.

These formulas do not apply to pulley ratios greater than 6 to 1. In fact, it is better not to exceed 5 to 1, if possible. The smaller the ratio the more satisfactory the formulas. High ratios are objectionable because the point at which the belt makes the cross is always close to the smaller pulley. And the wider the belt the more serious this objection because of the rubbing of the belt against itself.

It is possible to cross belting 10 in. in width, but it is necessary that the distance between the shaft centers be ample; the pulley ratio should not be greater than 3 to 1. Belting 8 in. in width is usually regarded as the limit.

High-grade, double belting gives better results than single belting, which is the reason why double thickness is usually recommended.

It is advisable to run the tight side to the top of the smaller pulley wherever practicable regardless of whether the small pulley is the driver or the driven pulley. Best results are obtained when the smaller pulley is the driver.

Belt pliability is of considerable importance. Use a high-grade, flexible leather belt.

There is no definite maximum center distance for crossed belts. It is possible to run a crossed belt at a center distance as great as that of an open belt. A crossed belt will pull a greater load without slipping, but nevertheless should not be loaded more heavily than an open belt. W. F. SCHAPHORST.

Newark, N. J.

Avoiding Sagging of Belt on Vertical Drives

We are well aware of the fact that vertical belt drives are often troublesome, but the conditions encountered in some rearrangements that are being made will necessitate the use of several drives that will be approximately vertical. We are using leather belts, and the driving motors range from 5- to 20-hp. rating. Will some readers tell me what is the smallest angle from the vertical that will overcome the sagging of the belt away from the bottom pulley? If we can obtain this angle we may be able to avoid, or lessen, any trouble.

Youngstown, Ohio L. A. M.

REFERRING to L. A. M.'s inquiry, the answer depends a good deal on the belt tension used, and also on whether the belt is run with the driving side on the top or on the bottom. In the latter case, if the slack side of the belt makes an angle of 15 deg. with the vertical it should lay over the motor pulley sufficiently to avoid trouble.

If this angle can not be obtained, sufficient tension can be applied to avoid trouble by mounting the motor rails vertical on a post or angle frame and turning the motor endbells 90 deg., so as to make the take-up vertical. Or, one of the several forms of weighted idlers on the market can be applied.

We have used both methods and prefer the vertical-rail system for small motors—5 or 10 hp.—and the idlers for larger motors. We are using them on drives up to 200-hp. rating.

H. D. FISHER.

Plant Engineer,
New Haven Pulp and Board Company,
New Haven, Conn.

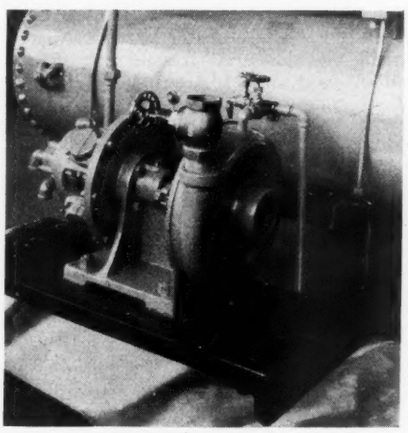
EQUIPMENT NEWS

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these devices, which are designed to improve plant operation or reduce operating and maintenance costs.

Ingersoll-Rand "ACV" Air-Motor-Driven Pump

AN air-motor-driven pump, known as the ACV, has been announced by the Ingersoll-Rand Company, 11 Broadway, New York, N. Y. The pump is a Cameron single-stage, single-suction, open-impeller, volute type and is driven by a four-cylinder air motor.

It can be mounted on a shelf at the rear of a portable air compressor. In this position, the connecting pipe between the air receiver and the motor

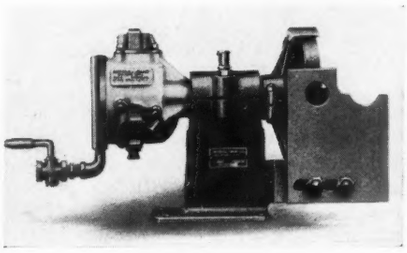


will not interfere with the operation of the hose line supplying air to the drills.

The capacity of the pump, with 60 lb. air pressure at 1,000 r.p.m., is 130 g.p.m. against a 29-ft. head. With 80 lb. air pressure at 1,200 r.p.m., the capacity is 125 g.p.m. against a 43-ft. head. These figures are based on a 20-ft. suction lift.

Ingersoll-Rand Air-Motor Driven Pedestal Grinder

A BENCH-TYPE pedestal grinder, air-motor driven, known as type 9, which can be bolted to a bench or a portable air compressor, has been introduced by the Ingersoll-Rand Company, 11 Broadway, New York, N. Y. The flow of air to the motor is controlled by a hand-operated globe valve. The machine has a free speed of 3,000 r.p.m. and is designed to take a vitrified grinding wheel 6 to 8 in. in diameter with a ½ in. face. At the end of the grinder spindle a bit chuck is screwed to take a drill or reamer with ½ in. straight shank.

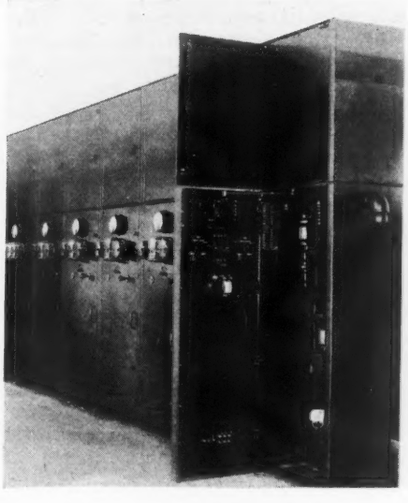


The motor has three interchangeable cylinders spaced about the center line of the spindle. All deliver power to one crank pin. The motor operates in a bath of lubricant. Exhaust is directed through the base of the machine—a feature which prevents the grindings from being blown into the face of the operator. A steady-rest in front of the wheel aids the operator in holding the work.

Standard equipment includes one 8 by 1 in., No. 24 Grade Q, vitrified wheel for iron and steel grinding, and one bit chuck for ½ in. straight shank or reamers. The necessary wrench is also included.

Westinghouse Indoor Cubicle

WESTINGHOUSE Electric and Manufacturing Company, East Pittsburgh, Pa, has recently announced a line of indoor, cubicle-type, switching equipment. The cubicles, consisting of oil breakers and vertical-swinging panels, with disconnecting switch



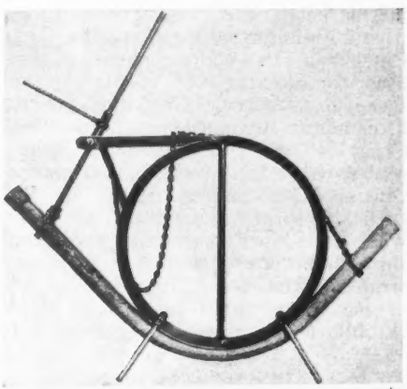
compartments, may be used for the control of feeders, transformers, or generators, or for any other application calling for oil breakers and a switchboard.

Units are made for either manually-, a. c. motor-, or d. c. solenoid-operated oil circuit breakers and may be equipped with automatic reclosing equipment, which, if electrically operated, will reclose the circuit breaker a number of times on a predetermined schedule.

The cubicles are constructed of structural steel members ⅛ in. thick, welded together to form a rigid unit.

Allied "Heer" Pipe Bending Tool

A PORTABLE pipe-bending tool that will bend up to 4 in. pipe or conduit is being marketed by The Allied Sales Company, Inc., Pittsburgh Life Building, Pittsburgh, Pa. It is

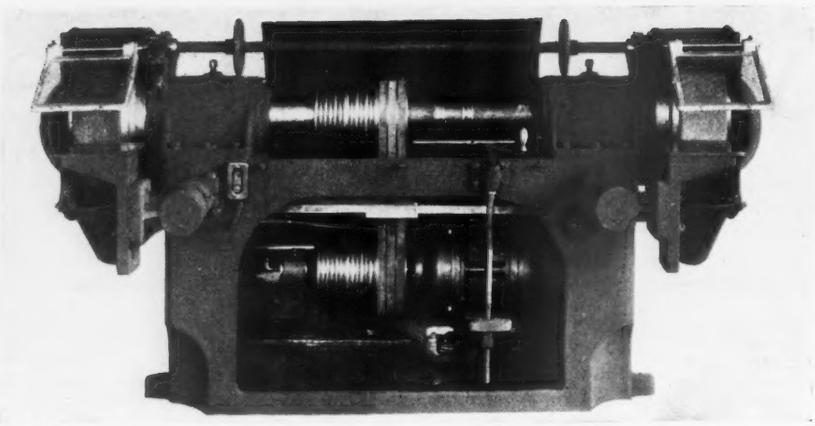


claimed that this unit will make bends without packing or heating, and without denting or caving the pipe.

The unit is made in five sizes and will handle all sizes of pipe up to 4 inches.

Standard Snagging Grinder

WORK rests and boiler-plate hoods with over-lapping covers, movable to accommodate all working conditions, are features of the 24-30-in. high-speed snagging grinder introduced by The Standard Electrical Tool Company, 1938 W. 8th St., Cincinnati, Ohio. A safety control device, which works in conjunction with the movement of the hoods, guarantees against over



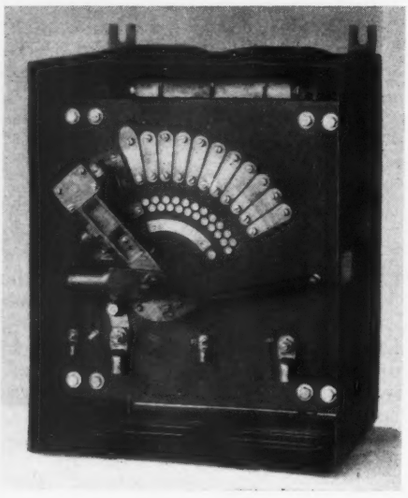
speeding wheels and assures a satisfactory working range of from 7,500 to 9,000 s.f.p.m. The spindle is 4 in. in diameter and 74 in. long, and is mounted in four SKF ball bearings. Three speed changes are obtained by three-step "V" belts and drive sheaves on the spindle and motor shaft.

Power is transmitted from the General Electric 40-deg. ball-bearing motor mounted in the base, to the spindle, through three, No. 6-03 Dayton "V" cog belts. The motor is raised and lowered by means of a lead screw for changing the speeds of the "V" belts, and at the same time assuring proper tension. The grinding wheels are of the ring type, 24 to 30 in. in diameter, with a 12-in. hole for 2 or 4 in. face, according to the rating of the motor.

Units are made with a 10-hp. motor for wheels 24 in. in diameter, and with a 15-hp. motor for wheels 30 in. in diameter.

Westinghouse D. C. Speed-Regulating Rheostats

THREE d. c. speed-regulating rheostats designated as Classes 7,350, 7,310, and 7,210, have been placed on the market by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. These rheostats are used for starting and regulating the speed of shunt or compound-wound, d. c. motors in non-reversing service, Class 7,350 being used where a 50 per cent speed reduction through armature control and 25 per cent speed increase by field control is desirable, Class 7,310 where a 50 per cent speed reduction through armature control only is desirable, and Class 7,210 where an increase up to four times full speed through field control is desirable.



With all these types of rheostats, the motor is started by moving the rheostat handle to the right. The contact arm is provided with a spring which returns to the "off" position in case of voltage failure. This affords low voltage protection and eliminates the possibility of the motor starting without all of the resistors in the circuit.

Square D and Diamond Electrical Merge

THE Square D Company, Detroit, Mich., and the Diamond Electrical Manufacturing Company, with headquarters in Los Angeles, Calif., have merged their interests, according to a recent announcement.

Hereafter the Diamond Electrical Manufacturing Company will operate as a subsidiary of the Square D Company. Both firms will distribute the Square D, I-C and Diamond E products.

General Electric "Electrolene"

AN industrial gas called "Electrolene," which is claimed to be better than hydrogen for many industrial applications, can now be produced by feeding steam and city gas or other hydrocarbons into an electric cracking device developed by the General Electric Company, Schenectady, N. Y. This gas is for use in furnaces where the atmospheres must be controlled for heat-treating processes, and also for metal cutting and other industrial operations.

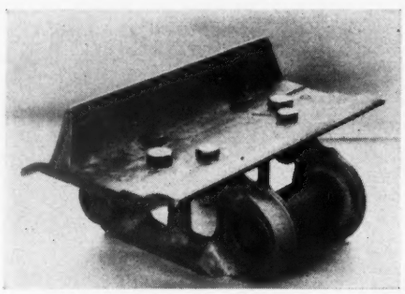
The heat necessary for cracking is generated by electricity. The cracking device occupies a small amount of floor space; a model for producing 1,500 cu. ft. per hour would be in the form of a cylindrical shell 7 ft. in diameter and about 10 ft. high.

Among other advantages claimed for this process are: the small amount of attention required; the flexibility of output, application, and operation; and the gas can be produced as required up to the limits of the equipment.

Chemically, the gas is composed largely of hydrogen and carbon monoxide. Small percentages of methane and nitrogen are also present, but carbon dioxide, illuminants, and oxygen originally present in the city gas are absent from the cracked product. The characteristics of the cracked gas can be varied somewhat in actual manufacture if necessary.

Caterpillar Tractor Track Shoe

A TRACK shoe for Caterpillar tractors that will withstand severe service has been developed by the Caterpillar Tractor Company, San Leandro, Calif. After many experiments, it has been possible to get a rolled steel shoe section.



It is only necessary to cut off, cope drill, and notch to produce a finished shoe, as shown.

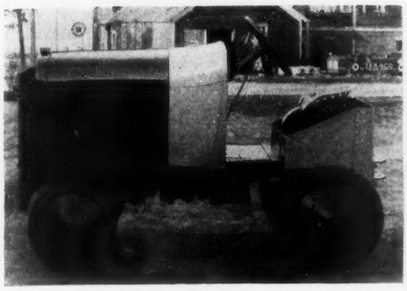
Hebard "Shop Mule" Gasoline Tractor

THE Shop Mule gasoline industrial tractor, Model J, made by the W. F. Hebard & Company, 551 W. Van Buren St., Chicago, Ill., is now available with standard Ford Model "A" parts.

The tractor is built on a 58-in. wheelbase, with a sharp angle of turn in the steer wheels, permitting a low turning radius. A worm-drive axle is employed with a reduction of 7¼ to 1.

One feature of the construction is the specially designed springs to withstand the strains of industrial truck and tractor service. The two front springs are cantilever style; the single rear spring is arched over the differential housing. A torque rod is used, thus relieving the springs of all driving strains.

A ¼-in. boiler-plate bumper, properly drilled for air circulation, is used,



not only as a radiator protection, but for pushing loads.

The coupler is a steel casting, designed for automatically coupling on to a loop hitch on a trailer.

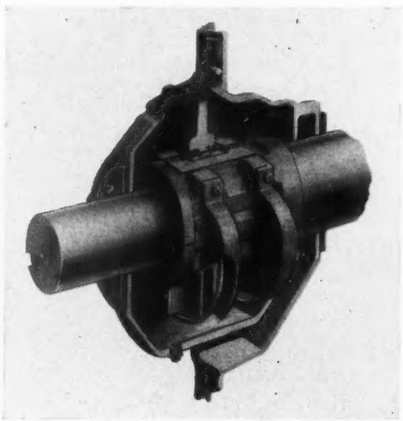
Nissly Floor Liner

TO define traffic aisles through a plant and to keep the work in progress in proper order, a floor liner has been developed by Walter S. Nissly, 43 N. Clinton St., York, Pa. The machine will paint a line as rapidly as the operator can walk, is easy to operate and handle, and can be moved in restricted places. It will draw a line within 1 in. of stationary objects, and any kind of paint can be used. Furthermore, the line is drawn from the side of the machine in full view of the operator. Gravity feed and easy cleaning are other features.

The paint tank has a capacity of 4 gal., from which paint is fed to the applicator by releasing a valve at the bottom of the tank. This is effected by means of a handle check. By moving the machine forward the bristles on the rear of the brush open ½ in., thus allowing the paint to be fed to the surface and brushed out, and giving uniform coverage and straight edge lines. When the applicator is drawn up from the surface, the rear bristles automatically close against the inserted flap, making a clean-cut stop of the painted line. The height of the machine over-all is 41 in., and the width and length are 13 by 18 inches.

Westinghouse Leakproof Bearings for Large Motors

IN the split sealed-sleeve bearing for large motors, recently introduced by the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., the oil rings, and other sources of oil spray are fully inclosed at all points above the level of the oil in the reservoir, the inclosures forming part of the bearing itself. The air space within the housing around the bearing is thus entirely separated from the chambers in which the oil rings turn, so that during operation of the bearing, as well as during period of rest, the air in this space is entirely free from oil spray. The interior walls of the housing remain dry, and leakage through and along the crevice between upper and lower halves of the bearing housing is entirely prevented.



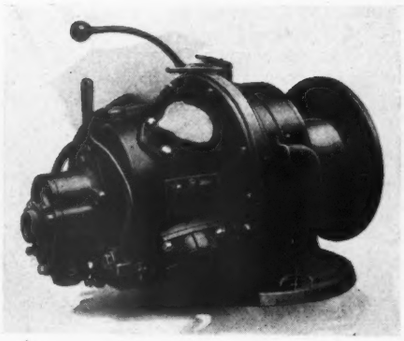
Leakage induced by windage is avoided, for, although a current of air may pass through the housing as induced by the suction of the blower, it cannot carry oil spray and vapor out of the housing as heretofore because the air in the housing is dry and clean.

Ingersoll-Rand "Utility" Air Hoist

A UTILITY portable air hoist of 2,000 lb. capacity has been introduced by the Ingersoll-Rand Company, 11 Broadway, New York, N. Y. Reduction gears between the motor and drum are all machine-generated spur gears and, wherever necessary, they are heat-treated to insure ample strength and wearing qualities. The gears are completely inclosed in a dust-proof housing and operate in a bath of semi-fluid grease.

The bronze throttle valve is tapered and is fitted into a bronze bushing. A clutch of the positive-jaw type is used to disengage the motor. This clutch is thrown out by an eccentric shaft controlled by the clutch lever which is conveniently located on the top of the hoist and automatically locks to hold the clutch either engaged or disengaged.

A brake of the band type wraps the drum at its largest diameter. The operating lever for the brake may be adjusted to any one of six operating positions. The motor also is inclosed in a dust- and dirt-proof case.



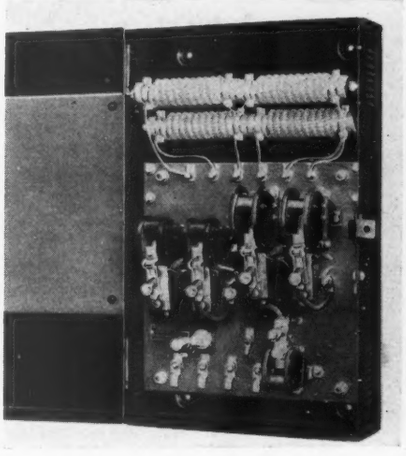
Southern Manganese Becomes Part of American Manganese Steel

ANNOUNCEMENT has been made that the Southern Manganese Steel Company, St Louis, Mo., has now become a part of the American Manganese Steel Company, Chicago Heights, Ill., and will be operated as the Southern Manganese Steel Division.

Until recently the Southern Manganese Steel Company was operated as a subsidiary of the American Manganese Steel Company.

Cutler-Hammer Lifting Magnet Controller

AN automatic lifting-magnet controller with an "automatic drop" arrangement is announced by Cutler-Hammer, Inc., 150 12th St., Milwaukee, Wis. The automatic drop feature relieves the lifting-magnet operator of an extra operation of the master switch each time the magnet is unloaded, giving him more time to operate the engine and brake levers and saving considerable time in loading and unloading.

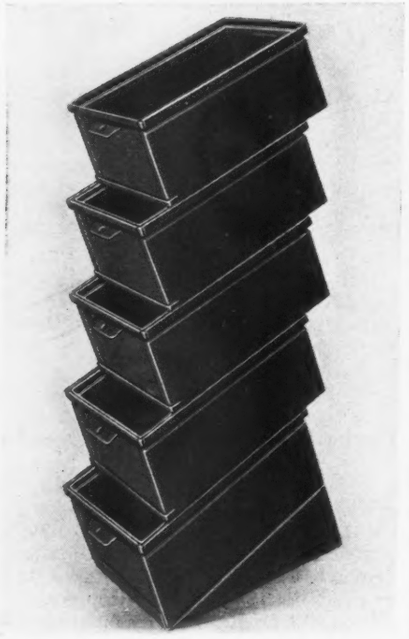


It is fully inclosed to protect the operator against shock and flying particles, and the controller against damage. The mechanism is mounted on an asbestos lumber panel which is moisture proof and built to withstand heavy shocks. Conduit knockout holes in the case facilitate wiring.

Although designed to operate with C-H "Red Top" lifting magnets, this controller can also be used with any other make or magnet.

All-Steel Box-Stacking Arrangement

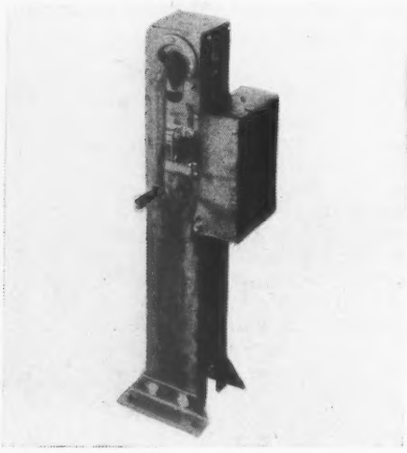
A SIMPLE arrangement for stacking boxes, which saves shop space and reduces handling operations, has been worked out by the All-Steel-Equip Company, Aurora, Illinois.



Boxes are stacked on a slant base and a spacer placed on the stacking rim on the front of each box. The space can be changed to accommodate the size of the part stored. Since the stacking boxes rest at an angle, parts will automatically roll to the front and stock is always seen at a glance. With this arrangement, inventories can be kept by box measure and full boxes added when the stock is depleted.

Champion Pedestals for Disconnecting Switches

A LINE of pedestals for operating gang-operated heavy-duty disconnecting switches has been developed by the Champion Switch Company, Kenova, W. Va. The vertical operating shaft at the top end has miter gears driven by a handle, the lower end a universal joint enabling the operating pedestal to be set over the shaft and



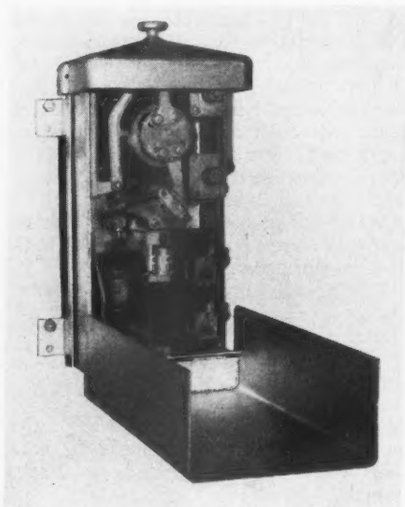
bolted down without special aligning. An operating indicator shows the direction to turn for opening and closing; the handle locking in both positions.

A wing extension on the shaft-traveling nut acts as a positive stop in both positions, a plate indicating the switch position. An extension on this nut strikes a bolt easily adjusted to stop the operating handle in the proper position. Each pedestal has inclosed contacts in series with the oil breaker operating circuit, opening this circuit unless the disconnects are in the fully open or closed position.

General Electric Motor Mechanism for Disconnecting Switches

GENERAL Electric Company, Schenectady, N. Y., announces the type MR-5 motor mechanism for use with outdoor disconnecting switches. This mechanism is a light-duty type for pole or bracket mounting and is suitable for application to outdoor group disconnecting switches 44 kv. and below.

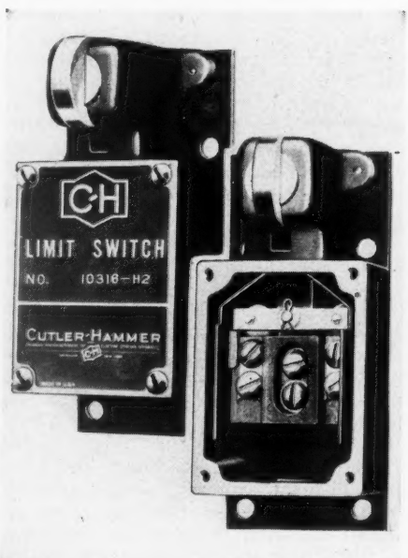
The device consists of a ½-hp. motor directly connected to an inclosed reduction gear, with a cam-type spring-pressure brake. The main driving shaft from the gear box extends through the rear of the housing, and to this is attached the switch-operating crank which rotates to 180 deg. in both the opening and closing strokes.



The housing inclosing the mechanism is an iron casting with a protective coating of aluminum paint. In the closed position, the housing is weatherproof. Auxiliary switches and motor control contactors are furnished inclosed in the housing.

Cutler-Hammer Limit Switch

A SINGLE-POST limit switch for general service is announced by Cutler-Hammer, Inc., 150 12th St., Milwaukee, Wis. This unit can be applied on machine tools, conveyors, washing machines, and other small



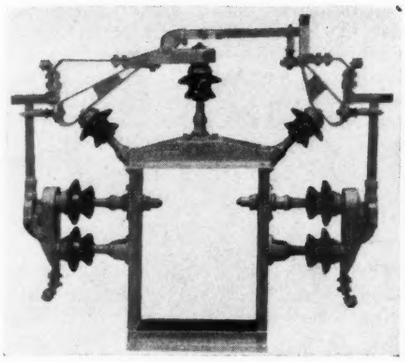
equipment, to start, stop or reverse the motor at its limits of travel.

Two types are furnished; one with normally closed contacts which are opened when the operating roller is depressed, and the other with normally open contacts which are closed when the roller is depressed.

Delta-Star MA39 Disconnecting and By-Pass Switch

FOR outdoor substation service, the Delta-Star Electric Company, 2400 Block Fulton St., Chicago, Ill., has developed a vertical-break switching unit which is claimed to effect a reduction in insulators, space required, and field wiring. It is a three-pole combination, designated MA39, consisting of 3 single-pole units, as shown; each unit being completely factory assembled and shipped ready for installation.

The top switch is for by-passing; the side mounted switches are disconnects for the oil circuit breakers. The line

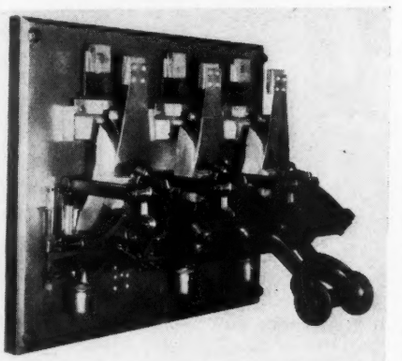


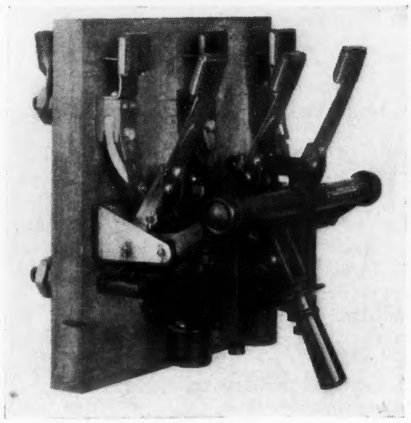
and bus conductors connect to the top switch element terminals, the oil circuit breaker leads being connected to the lower terminals of the side mounted switches. All operating mechanisms are located within the rectangular steel frame and connected to their respective operating handles.

General Electric Trip-Free Air Circuit Breakers

A LINE of "trip-free" air circuit breakers has been placed on the market by the General Electric Company, Schenectady, N. Y. The principal advantages of these breakers are: trip-free from the handle on overload; there is triple contact; there is no burning on the main brush; burning tips are easily replaced; high-pressure main contact is formed by laminations which make "end-on" contact with heavy and uniform pressure. The breakers are available for either instantaneous or time-delay automatic operation in either single-, double-, or triple-pole combinations with necessary accessories. A high-grade finish makes them particularly applicable on building equipment switchboards.

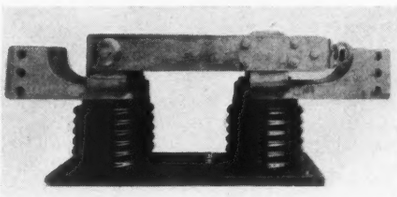
There are three classifications of breakers for voltages of 650 volts and below: Type CN-1, illustrated, is a compact breaker applicable to industrial service and for circuits in buildings where the current is from 3 to 300 amp. Type CP-108 is a breaker for moderate service rated 1,200 amp. and below. Type CK-8, illustrated, is a heavy-current breaker for moderate or heavy-duty service ranging from 1,600 amp. upwards.





Champion Disconnecting Switch

THE Champion Switch Company, Kenova, West Va., has developed a line of high capacity, S.P.S.T.F.C. indoor disconnecting switches with double blades, safety locks, and terminals for various busses.



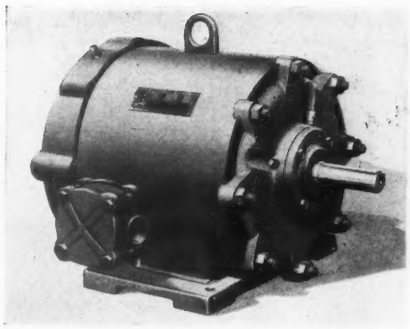
The design is such that but few parts are required and these are attached as units to the corrugated insulators.

Arrow Locking Ring for Convenience Outlet

NO. 7736 locking ring, which may be attached to all single convenience outlet plates, has been announced by Arrow Electric Division of The Arrow-Hart & Hegeman Electric Company, Hartford, Conn. When used with either Arrow parallel or tamden-blade locking attachment plug caps RE and TE, it makes a permanent connection between the cap and the receptacle. They cannot pull apart from twisting or pulling cords.

Allis "Explosion-Proof" Motor

BALL-BEARING, squirrel-cage motors of the self-ventilated, explosion-proof type, in sizes from ¼ to 25 hp., are now being made by the Louis Allis Company, Milwaukee, Wis. The motor proper is built in a totally inclosed metal casing which consists of a welded steel stator unit and two cast iron bearing brackets held together by eight tie bolts. This casing incorporates two of the explosion proof features of the motors, namely: the ability to retain the flame, and the strength to withstand the pressure in the event of an internal explosion.



An outer sheet-steel shell, large enough to allow a ½-in. air passage, surrounds the motor. A blast of cooling air is forced through this passage by an aluminum fan mounted on an auxiliary shaft extension.

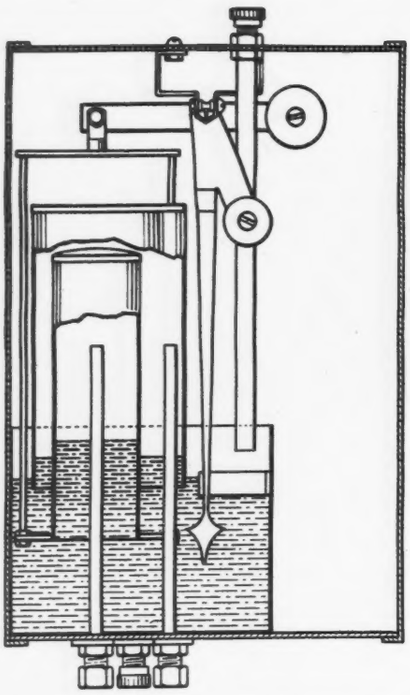
Delta-Star Hot Line Clamps

DELTA-STAR Electric Company, Chicago, Ill., has developed an improved type of hot-line clamps for making permanent connections to switches, transformers, lightning arresters, cutting in tap lines, for jumpers on transformer lines, for by-passing, test clamps, ground clamps and work on aluminum and copper conductors.

For normal distribution service, the clamps are used to tap off individual transformers without installing disconnecting switches. They are operated by a hook stick with a snap-type socket.

Ellison Air Filter Gage

FOR indicating the differential pressure across, or the resistance through, air filters, either of the oil or airmat type, the Ellison Draft Gage Company, Chicago, Ill., has adapted its new differential dial-type draft gage



with the double-bell movement to show when the filter needs attention.

A clean filter indicates a low resistance by a low reading on the scale. As the filter gradually becomes foul, the pointer moves correspondingly over the scale until a point is reached where the filter needs cleaning.

Westinghouse Phos-Copper Welding Alloys

WESTINGHOUSE Electric and Manufacturing Company, East Pittsburgh, Pa., announces its Phos-Copper welding alloys in both rod and strip form.

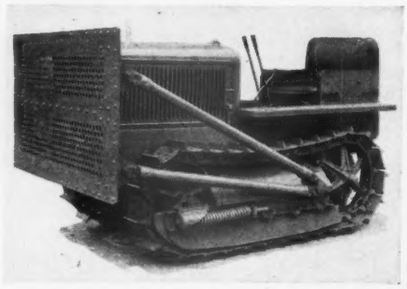
These alloys are composed essentially of copper and from 5 to 10 per cent phosphorus, the rod form containing slightly more phosphorus than the strip form. The fluidity of the material is directly proportional to the phosphorus content.

The presence of the phosphorus prevents the oxidation of both the copper and the surfaces being joined, thereby acting as a flux and producing a sound and dependable joint. At the same time, the phosphorus lowers the melting point and gives the alloy the characteristic of flowing freely when fused. The phosphorus partially burns out, leaving a uniform joint or connection.

Caterpillar Push Plate for Model 10 Tractor

A PUSH plate or front bumper has been designed by the Caterpillar Tractor Company, San Leandro, Cal., for its Model 10 tractor to increase its adaptability.

This push plate enables the tractor to push cars without the use of chains on bars. It also has a practical application where crates, boxes, trailers, etc., must be moved a short distance. The front plate is 59¼ in. wide by 34⅝ in. deep, and the bottom edge is



approximately 16 in. from the floor when the tractor is equipped with standard tracks.

Side members of the assembly come within the outer edge of the push-plate unit.

Baker-Case Machinists' Chests

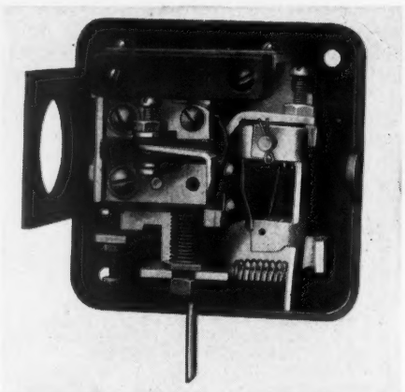
THE Baker-Case Manufacturing Company, Inc., Racine, Wis., has introduced a line of leatherette and quarter-sawed oak machinist chests, consisting of four models.

Many features have been incorporated. Among these is the steel drawer runner type of construction which insures permanent and positive ease in the use of the drawers. More spacious drawers have been created for holding a greater number of tools. The front doors of the chest are fitted with a steel rail at the bottom which insures further permanence.

General Electric Thermostat

THERMOSTAT No. CR-2992-A-1, for use with industrial heating units where very close control of the heat is not required, has been announced by the General Electric Company, Schenectady, N. Y. The device is available in three principal ratings, and the operating ranges are: 60 to 200 deg. F.; 150 to 300 deg. F.; and 250 to 400 deg. F. The current-carrying capacity is 15 amp. at 115 or 230 volt a. c., or ¼ amp. at the same voltages d. c. It will operate with a differential of 5 per cent of the maximum temperature range.

The unit is mounted on a pressed-steel base which has two mounting holes and an upturned ear with an opening for a ¾-in. conduit. A drawn-shell cover, held in place by two screws, completes the inclosure of the switch. Cover and base are finished in black Duco. Clearances between all live parts and ground are in accordance with Underwriters' specifications. Steel parts are cadmium plated

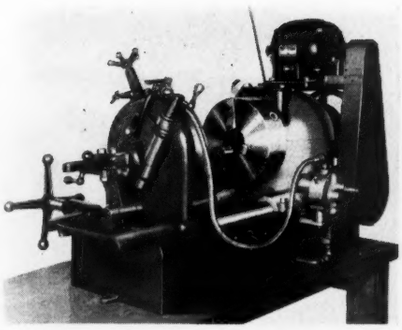


to resist corrosion. The capillary tube consists of copper tubing of ⅛ in. outside diameter, having the bellows sealed on the switch end and the bulb on the immersion end.

Oster-Williams Portable Power Threaders

THE Oster Manufacturing Company and The Williams Tool Corporation, Cleveland, Ohio, has announced that it is now equipping all Willie-Williams portable power threaders with Domestic Electric universal motors. It is also stated that the power threaders can be furnished in either the bench type or pedestal type.

Among the features claimed for these machines are built-in cutting-off,



reaming and chamfering tools, the built-in quick-opening die head that eliminates backing off, the geared oil pump, and two chucks—one a heavy gripping chuck and the other a self-centering universal chuck.

Both the bench type and pedestal type machines will thread, cut, ream and chamfer all sizes of pipe from ¼ in. to 2 inches.

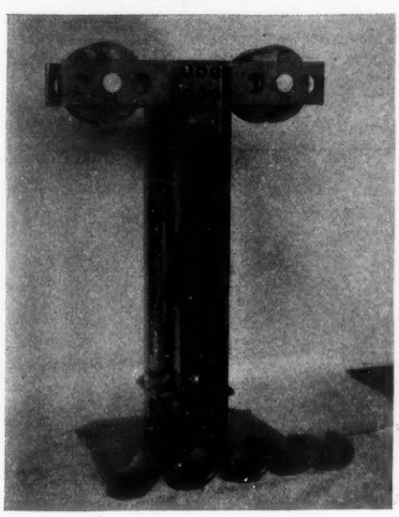
Lincoln "Lightweld" Electrode

THE Lincoln Electric Company, Coit Rd. and Kirby Ave., Cleveland, Ohio, announces a welding electrode, known as Lightweld, for use on light gage material. It can be used on 16, 18, 20, or 22 gage in making a lap, butt, or corner weld and is claimed to give a dense weld free from pin holes.

It was designed to be used with a manual carbon arc and with from 30 to 60 amp. d. c. and is suitable for horizontal, vertical, or overhead work. The size of the rod is 1/16 in. in diameter and 30 in. long and is put up in 10 lb. containers.

Lidseen "Chicago" Hydraulic Pipe Bending Machine

IMPROVEMENTS on the No. 4 Chicago 30-ton hydraulic pipe bending machine have been announced by Gustave Lidseen, Inc., 830 So. Central Ave., Chicago, Ill., as follows: the jack handle has been turned to operate from the side, permitting the operator to make any angle bend without getting in way of pipe; it has two speeds, high speed raising pipe up to contact with rollers quickly, and slow speed permitting a steady and effective pressure on pipe, bending it to angle desired.



All-Steel Storage Cabinets

A LINE of steel storage cabinets has been announced by the All-Steel-Equip Company, Aurora, Ill. Each of the four types offered is furnished in green baked enamel and have steel-angle and channel frames, with substantial body members to sustain heavy

weights. Standard equipment includes six sloping shelves with five adjustable partitions in each and one horizontal shelf near the bottom. Doors are panel re-inforced, with three-point latching device, vault type handles, and Yale lock.

General Electric Type TSA Automatic Time Switches

AN automatic time switch for closing and opening electric circuits at short predetermined intervals, and on a uniform schedule, has been introduced by the General Electric Company, Schenectady, N. Y. It automatically energizes a circuit to control intermittent operation of electric equipment. The time cycle may be a few minutes or several hours, and is repeated continuously. Owing to the short time of a cycle, one complete "on" and "off" period, the operation is without regard to the time of day.

The switches are single-pole, with one-way or two-way contacts, and are rated 5 amp. at 115 volts or 2½ amp. at 230 volts. On circuits of higher ampere rating, a magnetic switch can be employed in conjunction with the time switch.

The contact-making device is driven

by a Warren "Telechron" synchronous motor. A sheet-metal, dust-proof case is used for indoor mounting, with knock-outs and a hinged front cover that is secured by a latch at the top. A hanging lug is provided at the back for wall mounting.

Paasche Type UHT Hudson Striper

FEATURES of the Hudson Universal Striper introduced by the Paasche Airbrush Company, 1909 Diversey Parkway, Chicago, Ill., are: interchangeable nibs for a variety of stripes; revolving ball-bearing turret head with auto spring stop for circular striping; swivel adjustable guide with or without guidewheel; slanting swivel removable color cup assembly; com-

pression-needle packing eliminating sticking of needle or leaking of color; adjustable thumb-action lever for slow or fast color control; hand-fitted removable handle with air-space for cooling of hand; completely standardized with all parts interchangeable.

All-Steel Tool Chest

AN extra large and heavy tool chest, designed for manufacturers and installers of equipment in cases when it is necessary for the workman to carry a complete set of erection tools to each job, is being offered by the All-

Steel-Equip Company, Aurora, Ill. It is made of 14-gage steel, baked and enameled, and equipped with handles on each end. It is reinforced by bands on the top and bottom and around the cover. A hasp and staple for padlocking assures protection for tools. The chest is also being used on tractors and conveying machines bolted fast to the machine.

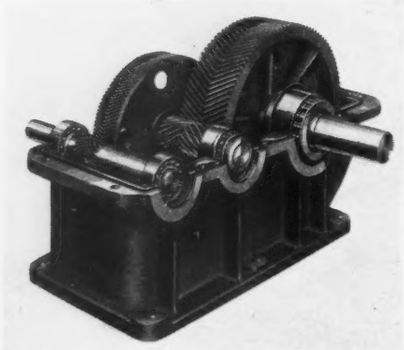
Foote IXL "Titan" Herringbone and Helical Speed Reducer

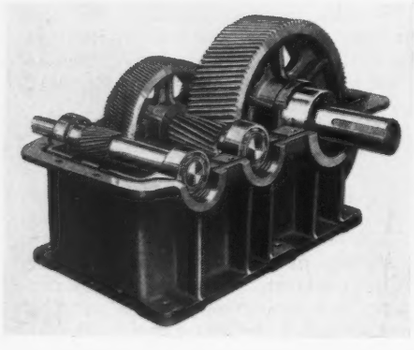
FOOTE Bros. Gear and Machine Company, 111 North Canal St., Chicago, Ill., has recently placed on the market a line of anti-friction speed reducers known as the IXL "Titans."

Units are available with either herringbone gears or helical gears, as desired. The two models are identical in design, with the exception that in one case the gears are of the herringbone type and in the other, helical type, with slight bearing modifications. The cases are cast from close-grained grey iron, treated to prevent flaking. Ribs are provided at each bearing for rigidity. The inside upper case is ribbed at the top as an added precaution against longitudinal vibration.

No gaskets are used between halves, as accurate machining makes this unnecessary. Oil return grooves are provided for the return of the oil to bottom of the case. Splash lubrication is standard.

SKF bearings are used on the high-speed shaft, and Hyatt roller bearings on the slow-speed shaft.



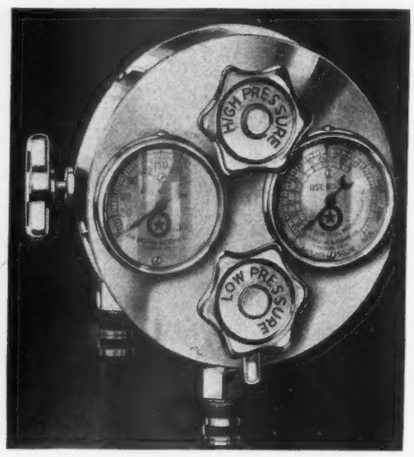


Bastian-Blessing "Red Star" Duplex Welding Regulator

AN addition to the Red Star line of regulators, the "Rego" Red Star duplex two-stage regulator for welding and cutting, has been introduced by The Bastian-Blessing Company, Chicago, Ill. A number of improvements have been incorporated in this model, among which are the following:

It is light in weight, compact, a single unit of two-stage construction—easy to take apart, strong, and has no delicate or easily broken parts. It is capable of delivering simultaneously to both welding and cutting torches, and maintains accuracy of pressure despite fluctuations in tank pressure.

The inlet connection is designed as a simple, removable joint. No special



tools are needed to take the regulator apart or put it together. Valve seats are designed so as to be easily reached from the outside.

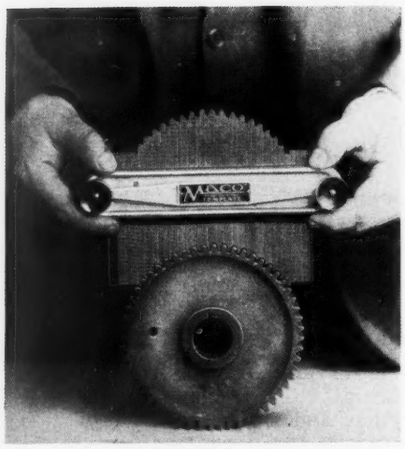
An alloy has been used with a tensile-strength of 55,000 to 65,000 lbs. per sq. in. Forged parts are used throughout.

Safety features common to this company's line of regulators are embodied in this model, including a non-igniting seat and nozzle construction.

American "Maco" Template

SET in an aluminum frame or housing, the Maco template introduced by the American Maco Template Company, 44 Whitehall St., New York, N. Y., is composed of a number of very fine strips of hard drawn brass, and is consequently rustless. The thickness of each strip is .007 in. These laminations are held in position by two special clamps which are fitted with sections of corrugated rubber which prevent them from falling out.

When an exact template of any profile is required, all that is necessary is to loosen the screws and gently press the adjustable template against the contour. The result of such pressure is that the laminations take a perfect outline of the surface against which they are pressed, their extreme thinness



materially assisting in the facility and precision of the process. When the pressure is complete, by merely locking the screws, the laminations are held in position. From the template thus produced, other and permanent templates may be made, or a record of the section of the profile may be kept and filed for further reference.

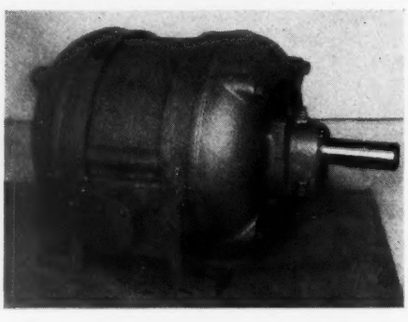
Cleveland Improved Design Semi-Inclosed Motor

IN the improved semi-inclosed motor recently brought out by the Cleveland Electric Motor Company, Cleveland, Ohio, the ventilating system has been redesigned and changes have been made in the construction of bearing brackets, fans, and end rings.

Baffles on the bearing brackets direct the air around the stator windings, and the end bells are so designed that the air current leaves the motor in an almost horizontal direction and sweeps over the outer face of the stator laminations. The outside flanges of the end rings are carried out some distance over the laminations to prevent dirt falling into the air passages or otherwise interfering with circulation.

This construction is now furnished as standard in squirrel-cage and slip-ring motors, both in the ball-bearing and sleeve-bearing types, for general purpose multi-speed or elevator applications. In a modified form, it is also used for fan-cooled totally inclosed motors.

An important claim made for this motor is that it can be used on either 2- or 3-phase circuits without any magnetic hum.

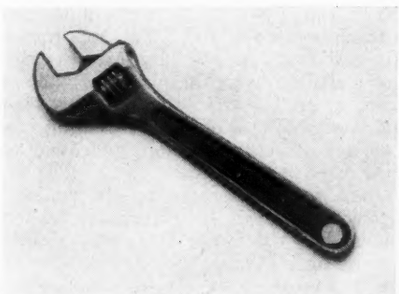


Reliance Stainless Steel Lockwashers

A STAINLESS steel for lock-washers has been perfected, according to an announcement by the Reliance Manufacturing Company, Massillon, Ohio. The company is now prepared to furnish the trade with these lockwashers in any size or section. It is claimed that in addition to having all the qualities of a non-corrosive stainless steel, they are of a spring temper equal to that of the ordinary steel lockwasher. The steel is drawn by a special rolling process, by which it is finished in a Brinell of sufficient hardness to produce the stiffness and reactive pressure necessary in a lockwasher, and makes subsequent heat-treating unnecessary. This company is also in a position to furnish the trade with stainless steel in coil or straightened and cut to length in any small section—round, flat, square, or hexagon—from 0.022 to 5/16 inch.

Keystone Adjustable Wrench

AN adjustable wrench with a square-top bearing, and forged from molybdenum alloy steel, has been introduced by the Keystone Manufacturing



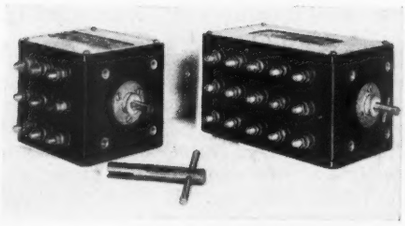
Company, 41 Chandler St., Buffalo, N. Y. The square-top bearing surface prevents wedging and spreading action, and also allows a heavier web section in the jaw.

Four sizes are available, 6, 8, 10, and 12 in. and three finishes; super-chrome, polished, and semi-finish. All wrenches are guaranteed.

Meter Devices Meter and Relay Test Switch

METER Devices Company, Canton, Ohio, has announced a test switch designed to facilitate testing of meters and relays.

As will be seen by the illustration, the "Roto Test Switch," as it has been named, consists of a one-piece Bakelite case with removable top and bottom covers, in which is mounted a rotor on a square steel shaft. This shaft extends through the front of the case and becomes the media for operating the switch by use of a specially designed key. Phosphor-bronze contact jaws are mounted on both sides of the



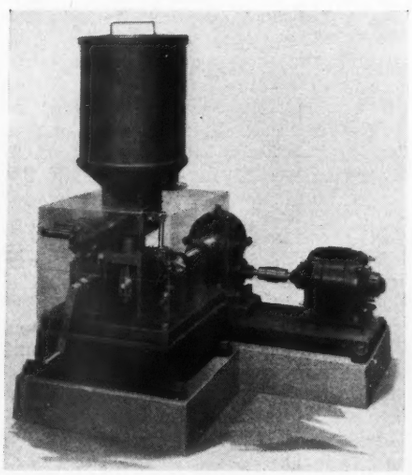
case and specially designed knife blade assemblies complete the mechanism.

Switches are made in four, six, eight, and ten-pole combinations for switchboard mounting. Units can be applied to any type of switchboard and used with all standard makes of instruments, meters, and relays.

Hill-McCanna "Anderson" Grease Pump

MEASURED quantities of grease are delivered to from four to twelve bearings by each "Anderson" grease pumping unit. This device, shown in the accompanying illustration, has been placed on the market by the Hill-McCanna Company, Chicago, Ill. It is positive in operation, and will maintain a pressure up to 5,000 lb. per sq. inch.

Present models consist of 4, 6, 8, 10 and 12 feeds per unit. Special sizes up to 24 feeds per unit may be obtained. The grease hopper has a capacity of 60 lb. A screen is installed



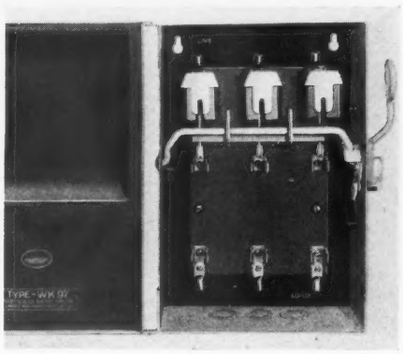
beneath the steam heating element to remove any foreign matter before the grease enters the pump.

Westinghouse Safety Switches

A LINE of quick-make and quick-break Type "C" safety switches, designated as the Type WK-97, is announced by The Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa. The switches conform with the Underwriter's new test procedure.

This line incorporates the "De-ion" arc quencher on the 575 volt sizes and many other safety features. The arc quenchers, consisting of nickel-plated, slotted steel plates held in place by insulating holders, are mounted individually over each jaw and are easily removed from the front if it is desired to remove them for wiring.

The operating mechanism is actuated by a compression spring which as-



sures a positive quick-make and quick-break. In case of a broken spring, external operation of the switch is possible.

The crank and all unpainted steel parts are cadmium plated to prevent oxidation. Other features of the line are: dust-proof crank bearings with grease packing; knockouts, pressed back into the box to decrease the filtration of dirt and excessive moisture; bases of Monson slate; lock-on and lock-off brackets.

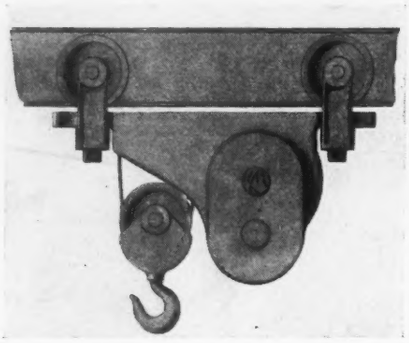
Gerstner No. 42 Tool Chest

H. GERSTNER AND SONS, Dayton, Ohio, has designed a tool chest, style 42. The deep-top compartment is 30 in. long and 8¼ in. high, and has a saw rack and holder. Provision has been made to take care of smaller tools in a series of felt lined drawers. These measure 4¼ in., 8½ in., and 14¼ in. long and range from ⅞ in. to 2 in. in height. The front lid has a self-hinging device permitting it to slide on steel bearings under bottom drawer, and to lock automatically when the top lid is down.

Robbins & Myers "Bantam" Hoist

ROBBINS & MYERS, INC., Springfield, Ohio, Hoist & Crane Division, announce the "Bantam" hoist as the latest addition to its line of electric hoists.

Among the outstanding features are



the following: Light weight, 130 lb. complete with trolley; small size, overall dimensions of 18x24x14 in.; speedy operation, 30 f.p.m.; capacity, 500 lb.; specially designed hoist motor fully protected against dust and moisture; simple and positive lubrication system; aluminum finish applied to entire hoist.

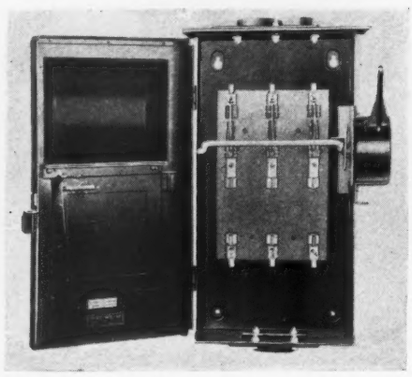
The unit is manufactured in styles for use on both a.c. and d.c. circuits with either rope or push button control. The frame design permits the use of the standard I-beam trolley or any make of monorail trolley.

Westinghouse Weatherproof Safety Switch

WESTINGHOUSE Electric and Manufacturing Company announces its Type WK-55 outdoor safety switch, designed to meet the outdoor requirements of industrial plants, mines, shipping yards, etc. It is similar to the standard WK-55 line, but has the following additional features:

A drip cover of special cadmium-plated steel which permits water to drip clear of the switch.

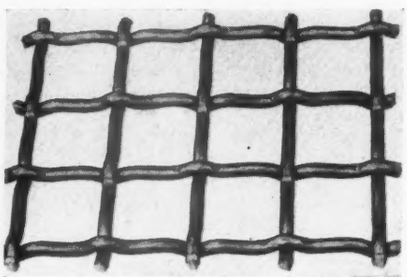
Cast-iron cadmium-plated fittings, which, together with gaskets, are bolted to the drip cover and box. The top cast fitting has two threaded openings, and the bottom cast fitting has one threaded opening which insures watertight joints for conduit.



Cadmium plating, which prevents rusting, is applied to the steel box and doors, the hardware, and the handle assembly. The base is made of ebony asbestos of high dielectric strength, and which is non-moisture absorbing and durable. All copper parts are tin-plated to prevent corrosion.

Ludlow-Saylor "Arch-Crimp" Woven Wire Screens

FOR application on equipment used for sizing coarse material such as stone, gravel, and coal, the Ludlow Saylor Wire Company, Newstead Ave. and Wabash Railroad, St. Louis, Mo., has developed the "Arch-Crimp" woven-wire screen. It will be seen in the illustration that no deep notches to break the wires are required. The wires have a gentle, graceful curve which, it is claimed, preserves the full strength and resilience of the steel. It is also claimed that tension will not



stretch the screen and that the wires resist abrasion. There is no sagging under load, no friction between the wires, and no wear from rubbing at the intersections. The screen is made with meshes having openings of 2½ in. in width down to ½ in.

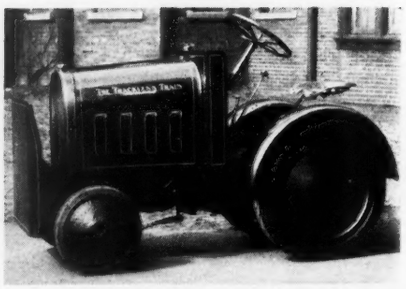
Mercury Type D Gasoline Tractor

AN industrial gasoline tractor, built to operate both outside as well as inside the plant, is announced by Mercury Manufacturing Company, 4118 S. Halsted St., Chicago, Ill. It is known as Type D.

This machine is powered with the Model A Ford 4-cylinder truck motor, and develops 40 hp. at 2,300 r.p.m. The clutch and transmission are the Model A Ford truck type. The disk wheels are of cast steel and equipped with solid pressed-on rubber tires. The front wheels are 18 in. in diameter.

Motor and radiator are cushioned from road shocks by long semi-elliptic front springs of alloy steel. Mercury's patented "balanced internal gear" drive axle is incorporated in this model.

Standard equipment includes electric self-starter, generator and battery, air cleaner, electric horn, standard coupler, ignition lock, and ammeter. Optional equipment consists of power take-off,



electric head and tail lights. The weight of this model is 3,500 lb. The normal drawbar pull is 700 lb., the maximum 2,500 lb. Its maximum speed under governor control is 10 m.p.h. Alemite system of lubrication is used throughout.

Reznor Gas-Fired Multiple-Unit Heater

IN the Type V, gas-fired, warm air heater now being put out by the Reznor Manufacturing Company, Mercer, Pa., two, four, six or eight combustion units can be grouped to form unit assemblies rated at 100,000, 200,000, 300,000, and 400,000 B.t.u. per hour. These figures divided by 240 give the equivalent steam radiation.

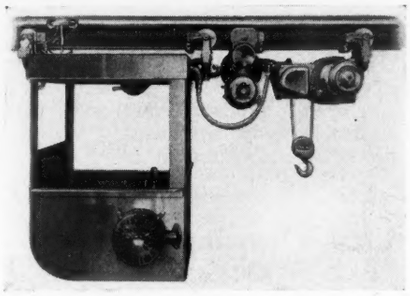
In the Type 2 UV unit illustrated, which is rated at 100,000 B.t.u., the base is cast iron; on the larger sizes angle iron is used, with the unit supported on two cross I-beams. Above the casing is mounted a housing containing the blower assembly, one fan and hood being used for each two units. The fan shaft which operates at 860 r.p.m. is carried on ball bearings and is connected to the motor through a flexible coupling.

The casing of the heater proper is a double-steel wall with ½ in. air space. The gas burners, of which there are four per unit, are automatically operated by a thermostat and motor gas valve. The air fans are automatically started and stopped at a point after the burners have been turned on or off, so that no cold air is circulated.

Louden Motor-Driven Trolley

A MOTOR-DRIVEN trolley is now being made by the Louden Machinery Company, Fairfield, Iowa.

Rope, push-button, remote or dis-



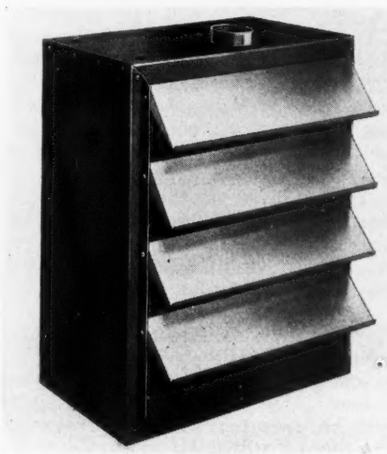
patch control are available, permitting the trolley to be operated the way best suited to the layout. The cab is open, closed, or furnished with a step-on platform when the operator must frequently dismount. All gears are inclosed, and moving parts that do not run in oil are reached by high-pressure lubrication of the Alemite type. All rotating parts, including the motor, run on ball bearings. The capacity is 4,000 pounds.

Copperweld Wires and Strands

TWO grades of copper-covered steel wire and strands, "High Strength" and "Extra High Strength," are now being made by the Copperweld Steel Company, Glassport, Pa., to replace the grades known as "Standard Tensile" and "Xtra-Hi-Tensile." The manufacturers claim that the improved products have an approximate increase of 50 per cent in strength over the old wires.

Bishop & Babcock "Massachusetts" Unit Heater

A CEILING - SUSPENDED unit heater, known as the No. 15 Massachusetts Type, has been announced by the Bishop & Babcock Sales Company, Cleveland, Ohio. The motor is of the totally inclosed type of standard manufacture, designed for

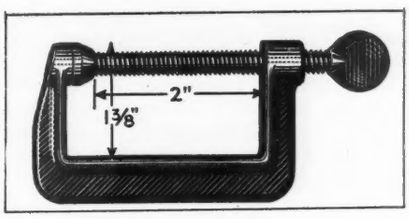


unit heater service. Single-phase a. c. motors can be furnished in the condenser type with three-speed switches, if desired. Bearings are bronze, wool packed.

The heating elements are tubes of seamless copper, rolled into headers of close-grained, gray cast iron. Casing is of heavy-gage, blue annealed steel, die formed. Individually adjustable louvres direct the heat where desired.

Brownie Clamp

STEEL clamps, known as "Economy Clamps," designed for light work, are now being made by the Brownie Manufacturing Company, Fort Wayne,



Ind. They are made in two sizes; No. 100, with a depth of 1-1/16 in., and screw opening of 1-3/16 in., and No. 200, with a depth of 1⅜ in. and screw opening of two inches.

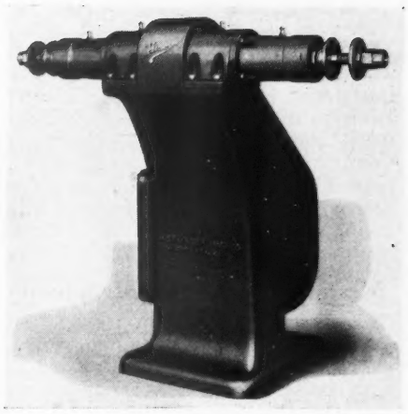
Roller-Smith Dry Cell Tester

TYPE BME No. 6 dry cell tester has been announced by the Roller-Smith Company, 233 Broadway, New York, N. Y. The current flow is

limited to about 6 amp. on a new cell and the instrument indicates whether the condition of the battery is good, medium or bad.

Hisey Model M TexDrive Buffer

THIS Model M TexDrive buffer recently introduced by The Hisey-Wolf Machine Company, Cincinnati, Ohio, is of gooseneck design The spindle and buffing wheels extend out from the base of the machine, permitting easy handling of large or odd-shaped pieces. This feature enables the operator to stand close or sit comfortably at the machine where the nature of the work permits him to do so.



The motor is ball-bearing equipped. The mounting is of the external type with a rigid, four-point support. It incorporates a dovetailed sliding base including gib with necessary locking screws. Adjustment is made by means of a handwheel and feed-screw.

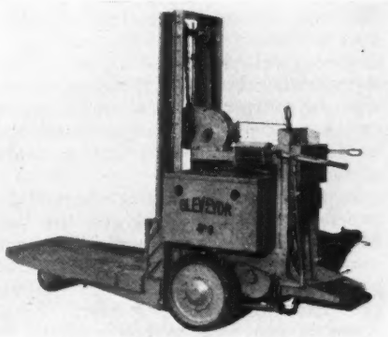
Mercury "Eleveyor"

A STORAGE-BATTERY conveying and tiering truck, known as the Eleveyor, has been announced by the Mercury Manufacturing Company, 4118 So. Halsted St., Chicago, Ill. Two models are available; Model A designed for high-lift work, and Model B for use where this feature is not essential.

Battery equipment can be varied to suit special conditions. The drive unit nut consists of a heavy-duty vehicle-type inclosed motor, 24 volts, 60 amp., 1,650 r.p.m. driving through Whitney roller chain, spur gearing, four-pinion Brown-Lipe-Chapin differential, six-spline, chrome-nickel-steel, full-floating axle drive shaft and heavy-duty, inclosed universal joints to the drive wheels.

Controller is of the Mercury drum type, three speeds forward and reverse. The hoist unit is a heavy-duty, vehicle-type inclosed motor, 24 volts, 40 amp. running at 1,800 r.p.m. A double-pole, double-throw, knife blade switch controls the motor. Automatic safety stops are provided at highest and lowest platform levels.

Normal capacity is 4,000 lb. Ball bearings are used throughout. Lubrication is by means of Alemite high-pressure fittings.

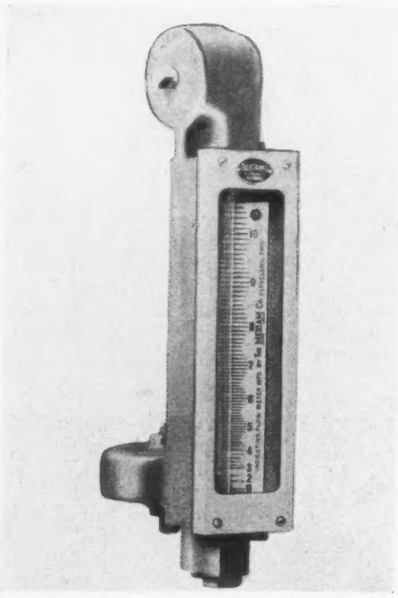


Arrow Receptacle

A SIGNAL device combining a bull's eye and flush receptacle has been introduced by the Arrow Electric Division of The Arrow-Hart & Hegeman Electric Company, Hartford, Conn. No. 7711 is made up with a brass face plate; No. 7728 is furnished with a Bakelite plate.

Meriam Well-Type Manometer

A WELL-TYPE manometer is now being manufactured by the Meriam Company, 1955 W. 112th St., Cleveland, Ohio, for the purpose of measuring the mixture of liquid or gaseous fuel used in furnaces for annealing, heat-treating, heating, chemical and process operating, and so forth.

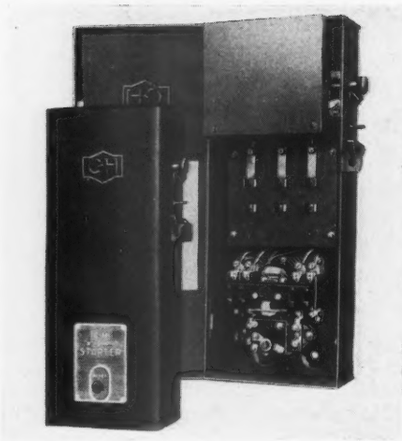


The instrument, which has hitherto been mainly used in the metal-working industries but which is of course adaptable to many others, is made up of a series of compact manometer units.

Cutler-Hammer A. C. Motor Starter

CUTLER-HAMMER, Inc., 150 12th St., Milwaukee, Wis., announce the development of an a. c. across-the-line, automatic starter combined with a fusible disconnect switch in a single steel inclosing case. This starter may be used in place of the separate starter and fusible disconnect switch requiring less space, simplifying installation, and presenting a neater appearance.

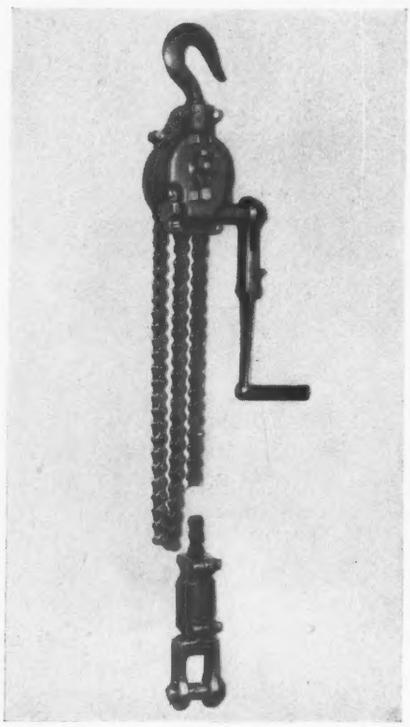
A feature is a wiring channel between the starter panel and the back of the inclosing case which allows running the connecting wires behind the panel where they cannot interfere with the operation of the starter. Ample room is provided to bring all of the



connecting wires in at either the top or the bottom of the case according to installation requirements. All parts are mounted on a back plate which is easily removed for pulling and placing of line and motor wiring.

Matthews "Pullift" Hoist

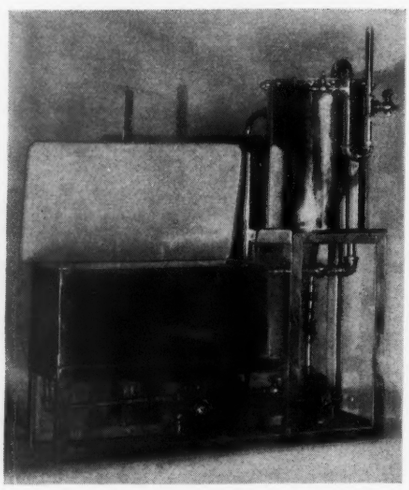
A ONE-MAN hoist, known as the Pullift, having a capacity of 5,000 lb., has been placed on the market by the W. N. Matthews Corporation, Forest Park Blvd., St. Louis, Mo. Any length of chain can be used, thereby multiplying the uses of the tool and greatly simplifying the work. The hoist will lift 1,000 lb. at the rate of 16 in. per min. and heavier loads proportionately. Safe operation is assured because the load is always carried on the tool and is not transmitted back to the operator through the ratchet handle.



A magazine provides a safe means of keeping the free end of the chain from coming into accidental contact and catching on the machinery hoisted. A hook or clevice is supplied on each end of the chain or a hook on one end and a clevice on the other. The hooks and clevices are interchangeable. The unit has a take-up of 5 ft., when the magazine is not used, and a maximum take-up of 4 ft. 7½ in. when it is employed. High-strength steels and malleable iron are used. Wearing pieces are heat-treated.

Dolph Varnish Dipping Tank

A MECHANICAL dipping tank for insulation varnishes is now being made by the John C. Dolph Company, 168 Emmett St., Newark, N. J. This varnish control unit does three things:



mechanically reduces varnish; filters the varnish every time it reduces it; and mechanically stores the varnish, preventing the oxidizing reactions of air with the prevention of solvent losses.

Cutler-Hammer Purchases Union Electric Manufacturing Company

ANNOUNCEMENT is made by Cutler-Hammer, Inc., Milwaukee, Wis., that it has purchased the assets of Union Electric Manufacturing Company, also of Milwaukee, manufacturers of motor control equipment specializing in a complete line of drum-type control apparatus.

The addition of the Union line to that of the Cutler-Hammer line enables Cutler-Hammer to supply any requirement of its customers in drum-type motor control apparatus.

The branch sales offices and warehouse stocks of Union will be consolidated immediately with the Cutler-Hammer branch offices and warehouses. The present factory of Union will be operated as a manufacturing division of Cutler-Hammer.

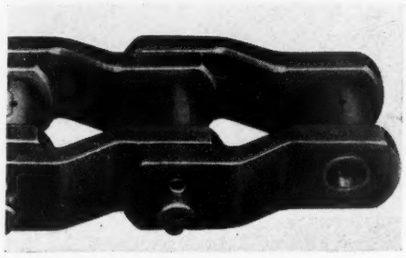
control is effected by a furnacestat or similar standard temperature switch.

Approximate over-all dimensions and fan capacities of the different assemblies are as follows: Front to back, all sizes, 36 in.; height to top of hood, all sizes, 87 in.; front width, Type 2 UV, 30 in., fan capacity 1,560 c.f.m.; Type 4 UV, 54 in., 3,060 c.f.m.; Type 6 UV, 78 in., 4,575 c.f.m.; and Type 8 UV, 102 in., and 6,100 c.f.m. The discharge air temperature is under 140 degrees.

Where sufficient headroom is not available to permit installation of the standard unit, a single-type fan may be set alongside of the heater, with down discharge and delivering the air to a concrete pit over which the heater and fan are set.

Link-Belt "Hyper" Chain

LINK-BELT Company, Indianapolis, Ind., announces the development of a steel drive chain which will be known as Link-Belt Hyper Chain. The chain is made from heat-treated alloy steel and uses an improved type of pin and cotter. The pins, bushings, and holes in side bars are accurately ground. The cotters are of a special type and are designed so as not to work loose



when once inserted and swelled into the holes provided in the pins for their reception.

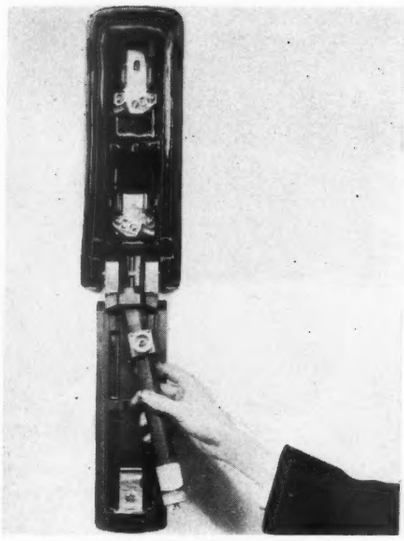
The SS-40 chain has an ultimate strength of 75,000 lb.; the SS-124 chain an ultimate strength of 150,000 pounds.

Westinghouse Primary Fuse Cutouts

WESTINGHOUSE Electric and Manufacturing Company, East Pittsburgh, Pa., announces a complete line of primary fuse cutouts, identified as Type ES, and which provide protection from overloads and short-circuits in distribution transformers.

The fuse cutouts are especially designed for cross arm mounting and are made in four sizes. The cutout cover is hinged at the bottom, and, when it is opened, the fuse is removed from all live contacts and to a distance which permits safe handling. The fuse tube then can be removed from the cover safely, easily, and without the use of tools. Its replacement is also effected without using tools.

Housing is made of wet-process porcelain of high dielectric strength. The cover is Moldarta, a molded insulating compound impervious to moisture The handle also is Moldarta and is molded integral with the cover.



All metal parts are plated to prevent corrosion; they are either clamped, sprung, or screwed into place, facilitating renewal.

The fuse tube is open at the bottom and closed at the top with a removable cap. When an overload or short circuit occurs, the fuse link blows and gas is expelled from the open end of the tube into the atmosphere. Insulation barriers at the bottom and in the housing prevent gases entering and causing arcing between contacts.

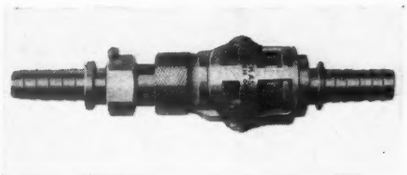
Delta-Star Unit-Type Auxiliary Switch

THE Delta-Star Electric Company, 2400 Block Fulton St., Chicago, Ill., has developed an auxiliary switch for use with oil- or air-break switches, motor-operating mechanisms, etc. The switch can be made to open or close the circuit at any desired position. If it is desirable to have one circuit opening instead of closing or vice-versa a simple adjustment permits this arrangement without taking the switch apart.

A single switch unit is illustrated. If desired it can be stacked twenty units high on a single mounting. The switch rated at 250 volts, 15 amp. will carry 35 amp. without exceeding A. I. E. E. specifications. Each unit is provided with card holders so that the circuits may be marked.

Hunt "Quick-As-Wink" Shut-off Valve

AN application of the by-pass principle is incorporated in the Quick-As-Wink shut-off valve and coupling announced by C. B. Hunt & Son, Salem, Ohio. A ¼-in. push or pull on the outer member is the only movement required to turn the flow of air on or off. In combination with Quick-As-Wink couplings, this valve allows air to be shut off anywhere on the hose



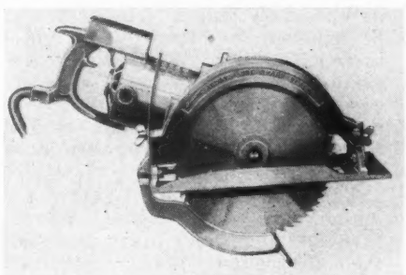
line, automatically bleeding air for removal of tools for repairs or oiling.

It is claimed that in spite of the free swiveling of coupling and valve, they are air tight from 1 oz. to 1,000 lb. pressure. The valves and couplings are made in all sizes from ⅛ to 4 inches.

De Walt Electric Hand Saw

ANNOUNCEMENT has been made that the DeWalt Products Corporation, Lancaster, Pa., has acquired the Wodack electric hand saw and the Wodack electric combination mortiser and router.

The Wodack hand saw is manufactured in four styles: Model K, weigh-



ing 15 lb. with a cutting capacity of 2⅝ in.; Model C with a cutting capacity of 4⅛ in.; Model B with the same cutting capacity as Model C, with the addition of a beveling feature up to 60 deg.; and Model D, for handling 4½ in. material. This last unit is powered by a 1-hp. General Electric universal motor and is also equipped with the beveling device.

Among the features found in the saw illustrated, are: no obstructions that force the operator to an unnatural position to observe the cut; a sawdust blower that keeps cutting line always visible; a convenient trigger switch and a gravity guard providing safety without sacrificing practicability. The entire motor tilts for bevel cutting.

Electric Controller Type NT Master Switch

INTENDED for use on cranes, hoists, and other applications where speed control from a master switch is desired, Type NT master switch has been placed on the market by The Electric Controller & Manufacturing Company, 2700 E. 79th St., Cleveland, Ohio. Refinements to insure smooth and easy operation include: ball bearings, short throw of the operating handle, the absence of gears, and the fact that the contact fingers always ride on uninterrupted plane surfaces. Also incorporated is an accurately machined, notched track, on which an improved roller-type centering device rides. This permits the operator to feel the various speed points and, of course, the notch in the "off" position is machined more deeply than the others.

The width of the switch has been kept as small as possible so that several units can be mounted in a crane cage or operator's pulpit. The switch can be mounted in either the upright or inverted position. As shown, it is entirely inclosed by a heavy-gage steel cover and is arranged for conduit connections. Both the contacts and the contact fingers are of improved design and are renewable.

The switch is built to give a maximum of six points of speed control in each direction, with overload reset at the "off" position. Master switches for 4, 5, or 6 points of speed control are identical, the only difference being the location of the arm stops. Since these stops are merely screwed into the main frame, they can be changed in the field to provide any one of these points of speed control.

G-M Laboratories Sensitive Relay

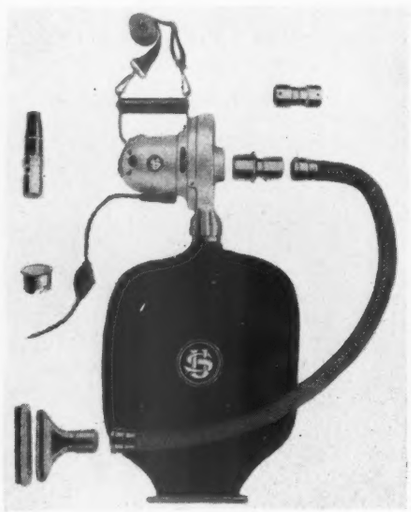
A SENSITIVE relay for use in conjunction with photo-electric cells has been perfected recently by the G-M Laboratories, Inc., Grace & Ravenswood Ave., Chicago, Ill. It is complete in itself, and embodies a one-stage amplifier using standard UV 199 type

tube which makes possible sensitivity to as minute a change in light intensity as 0.005 lumen.

The relay can be put to a multiplicity of uses in conjunction with photo-electric cells, some of them being the counting of moving objects, grading of materials according to color, inspection and testing of new and finished products, and smoke control. It also has many applications in the research laboratory.

United States Combination Blower and Vacuum Cleaner

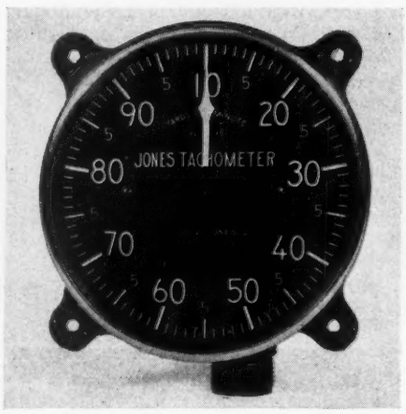
A CLEANER that does double duty about the shop is now made available through jobbers by The United States Electrical Tool Company, Cincinnati, Ohio. This tool not only provides a suction or vacuum cleaner for car interiors, stock bins, etc., but by removing the dust bag and changing the location of the hose, provides a blast of air that is useful for various kinds of drying and for blowing dust and other free dirt from motors, machines, etc. One of the features is its ease of handling. By hanging the motor and fan over one shoulder or on a convenient hook, the operator can get into places usually hard to clean or previously inaccessible.



The cleaner comes in two sizes complete with hose, nozzle, brush, canvas bag, and shoulder strap. No. 1 is 7½ lb. in weight, No. 2, 9½ lb. Universal motors are standard equipment. The body is aluminum and a quick-make, quick-break switch safeguards against short circuits.

Jones Industrial Tachometer

THIS instrument, designed for use in industry where a constant knowledge of exact machine speed is required, has been announced by the Jones-Matrola Sales Company, 370 Gerard Ave., New York, N. Y. Speeds may be indicated in revolutions per minute, feet per minute, yards per minute, revolutions per hour, etc., a large assortment of dials of various speed ranges being kept in stock.



With this tachometer, a visible and direct means of knowing exactly how fast machines are running is constantly available to operators. Usually, the instrument is driven by gears and flexible shafting, but it can also be belt driven.

General Electric Non-Metallic Sheathed Parkway Cable

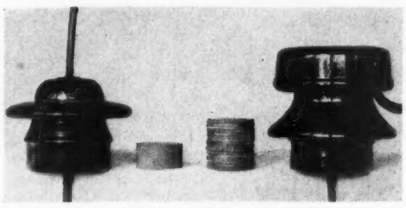
NON-METALLIC sheathed cable, introduced by the General Electric Company, Schenectady, N. Y., may be used in nearly every location where the metallic types were previously used. The construction of the cable, which has been designated as Type CA, incorporates the use of jute and asphalt.

In place of the metallic sheath previously used, successive wraps of hard, vacuum-impregnated, closely-woven jute have been substituted. To replace the steel tape serving as a shock retarder on metallic parkway cable and as protection against mechanical injuries, the new cable has been constructed so that it will have a cushioning effect against any hard object coming in contact with it.

The entire assembly is impervious to corrosive elements usually found in the ground.

Westinghouse Lightning Arrester

A MATERIAL that is both an insulator and a conductor, the particular state depending upon the voltage stress to which it is subjected, has been developed by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. This material, when placed in a circuit and voltage applied



to it, will act as an insulator, in other words, it will not pass any current when the applied voltage is below a certain critical value; when the applied voltage exceeds this critical value the material quickly changes into a conductor and permits the current to flow freely in any quantity necessary to prevent the voltage from rising to higher values. This material definitely limits the voltage that can exist through it.

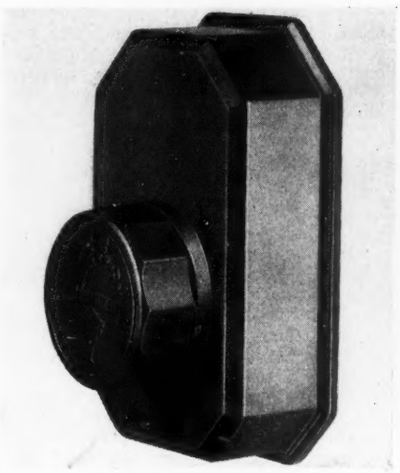
These properties make it particularly suited for use in lightning arresters whose function it is to hold down the voltages that may occur on transmission lines from lightning, and it is so used in the auto-valve lightning arrester, the elements of which are illustrated. The arrester works on the glow discharge principal, but the discharge takes place in the pores of the single disc.

American Mercoid No. 855 Thermostat

THE thermal element of the Mercoid No. 855 thermostat, introduced by the American Radiator Company, 40 W. 40th St., New York, N. Y., protrudes from the face of the instrument. The outer side appears as a cover and is exposed directly to the atmosphere and therefore very sensitive to air temperature changes. This construction eliminates the ventilating apertures in the cover and greatly improves the appearance of the unit.

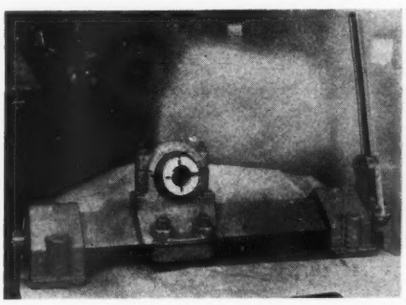
The incased fluid under the cover, as it expands or contracts, actuates a plunger by means of the inner bellows, and operates the movement by throwing the switch to the "on" or "off" position.

No. 855 requires no relay and will operate where the normal current working load does not exceed 110 volts at 10 amp. or 220 volts at 5 amp. The standard range of this model is from 56 to 80 deg. Fahrenheit.



Stephens-Adamson Conveyor Bearing

A ROLLER-BEARING belt-conveyor take-up bearing in sizes to suit the pulley shaft, and in maximum bearing travel to suit the length of the conveyor, has been introduced by



the Stephens-Adamson Manufacturing Company, Aurora, Ill.

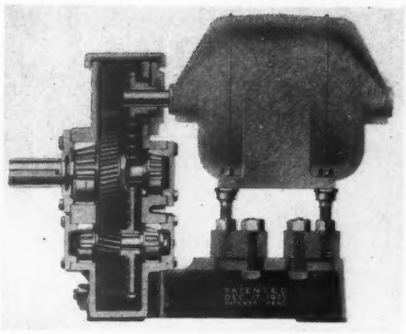
It consists of a structural-steel angle upon which slides a Timken bearing in a special self-aligning housing. The bearing is moved backward or forward by a screw, protected by the steel angle and operated by a ratchet lever designed for use in cramped quarters.

The takeup is furnished for shafts from 1 15/16 up to 4 15/16 in. in diameter and in sizes with a maximum shaft travel of 24 to 54 in. The inner race is fitted with an adapter which receives the shaft without turning or shouldering.

Cullman Improved Speed Reducer

SEVERAL improvements have been made in the speed reducer manufactured by the Cullman Wheel Company, 1346 Altgeld St., Chicago, Ill. Chief among these improvements is the substitution of Timken roller bearings for phosphor-bronze bearings. Another improvement is the use of helical gears in the place of spur gears. The first reduction is obtained by a chain and sprocket drive, from 2 to 6 times below the motor speed. This not only cuts down gear wear, but also reduces noise. The gears are supported by four Timken bearings which have the further advantage of taking up end thrust.

Changes have been made in the oiling



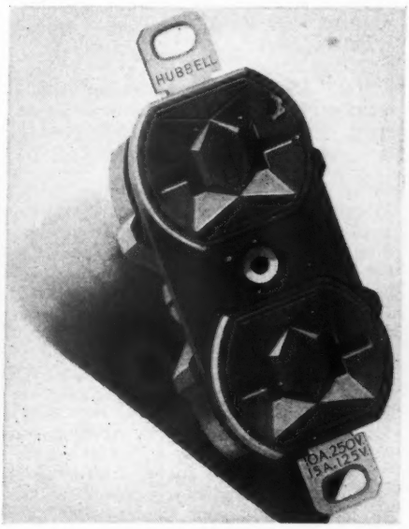
arrangement at the main gear bearing and at the point where the motor enters the reducer. At this latter point the hub of the sprocket has been extended into the oil chamber, replacing the ring previously used. A spray of oil is furnished at all points by the sprocket chain. At each bearing there is a circular recess with a bottom outlet which provides complete drainage of the oil back into the interior of the reducer, thus preventing leakage.

Hubbell Convenience Outlets

A SOLID, composition base, which eliminates the fiber back and which is moisture-proof, is one of the features of the convenience outlet being marketed by Harvey Hubbell, Inc., Bridgeport, Conn. A one-piece contact spring of phosphor bronze guarantees alignment and a positive electrical connection.

The binding plates and screws are in deep pockets with heavy side bosses of composition, well protected and insulated from the side of the wall and box. Bakelite barriers insulate the wiring cavity from the face plate. The tapped bushing for the plate screw is grounded to the mounting strap, thus grounding the plate.

A Bakelite face of modernistic design incorporates slot finders which make it easy for blades to find their slots quickly and easily. Units are made in both single and duplex types.



TRADE LITERATURE

You Should Know About

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog described, as given in these columns.

* * *

(143) METERS—Bulletin 79, Sangamo Type HC watthour meters, single and polyphase types.—Sangamo Electric Company, Springfield, Ill.

(144) NIBBLING MACHINES — Catalog, listing the complete line of Campbell nibbling machines.—Andrew C. Campbell, Inc., Waterbury, Conn.

(145) MOTORS—Bulletin 262, the "Weld-Built" d. c. motor.—Electro Dynamic Company, Bayonne, N. J.

(146) SWITCHES—Bulletin 506, Matthews Fusewitches and disconnecting switches, open type.—W. N. Matthews Corporation, St. Louis, Mo.

(147) FLOW METERS—Instruction Book 214, for the installation and care of Brown electric flow meters.—The Brown Instrument Company, Phila., Pa.

(148) CONVEYORS—Catalog 52, 80 pages, overhead and other conveyors.—Palmer-Bee Company, Detroit, Mich.

(149) MOTORS—Bulletin, Doublenclosed motors in various capacities.—United States Electrical Manufacturing Company, Los Angeles, Calif.

(150) INDUSTRIAL TRUCKS—Catalog 30-CT, industrial trucks, furniture casters, office equipment, and store fixtures.—Saginaw Stamping & Tool Company, Saginaw, Mich.

(151) SILENT CHAIN—Folder 1223, a history of the organization and development of the Link-Belt Company.—Link-Belt Company, Indianapolis, Ind.

(152) ARC WELDING—Bulletins 12 and 13 present the latest developments in arc welding and news of interest to designers and users of welding and welded products.—Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

(153) ELECTRICAL PRODUCTS — Catalog, the Dunco line of electrical products.—Struthers Dunn, Inc., 139 Juniper St., Phila., Pa.

(154) SAFETY — "Safety Competition," the seventh in a series of industrial safety leaflets, based on a study of the field of safety engineering and outlining effective methods of applying the principles governing successful accident prevention work.—Policyholders Service Bureau, Metropolitan Life Insurance Company, One Madison Ave., New York, N. Y.

(155) MOTORS—Bulletin 108, Type AA, Form L, across-the-line motors, with ball bearings, for two- and three-phase a.c. circuits.—Reliance Electric & Engineering Company, Ivanhoe Road, Cleveland, Ohio.

(156) ELECTRIC TOOLS—Catalog 32, 96 pages, shows the complete line of "Clark" electrically driven tools.—Jas. Clark, Jr., Electric Company, Louisville, Ky.

(157) WIRING PRODUCTS—"Catalog and Wiring Guide No. 12." Wiremold conduit fittings.—The Wiremold Company, Hartford, Conn.

(158) CABLE TERMINATORS—Bulletin 65-B, terminators for sealing the ends of lead-covered cables.—Delta-Star Electric Company, 2400 Block, Fulton St., Chicago, Ill.

(159) TESTING EQUIPMENT — Catalog D-1, Chevenard industrial thermal analysers and differential dilatometers.—The R. Y. Ferner Company, Investment Bldg., Washington, D. C.

(160) STEEL PRODUCTS—A booklet and two folders on sheet steel products. The booklet, "Inland Open Hearth Sheet Steel Products," briefly describes each of the many grades of steel sheets, gives standard extras and differentials, tables of tolerances and weights, and includes a section describing trade customs and practices. One folder, "Inland Gal-Van-Alloy Steel Sheets," describes coated sheet steel. The other folder, "Enduring Sheets at Low Cost," includes some interesting data on copper alloy steel sheets, rust and corrosion-resisting product. — The Inland Steel Company, Chicago, Ill.

(161) WOOD PRESERVATION — Leaflet, "The Battle to Preserve Materials," a copy of the radio talk delivered recently by Dr. Julius Klein, Assistant Secretary of Commerce.—C-A-Wood Preserver Company, 6625 Delmar Blvd., St. Louis, Mo.

(162) FIRE PROTECTION—Advance publications of the reports of the committees on "Construction Operations," "Protection of Openings in Walls and Partitions," "Tanks," "Manufacturing Risks and Special Hazards," "Hazardous Chemicals and Explosives," "Flammable Liquids," and "Automatic Sprinklers."—National Fire Protection Association, 60 Batterymarch St., Boston, Mass.

(163) RESISTORS—Bulletin GEA-1238, vitreous-enameled resistors; CR9006, CR9150, CR9151, CR9152, CR9153, CR-9157, CR9158.—General Electric Company, Schenectady, N. Y.

(164) IRON—The first 1930 issue of "The Pure Iron Era."—The Armco International Corporation, Middletown, Ohio.

(165) LIGHTING—Booklet C-1885, "The Way Out of the Twilight Zone," 32 pages on the value of proper lighting including numerous tables and formulas for designing and installing lighting systems.—Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

(166) TRANSFORMERS — Bulletin, air-cooled transformers, Type MD, in sizes from 5 to 25 kva. capacity.—Standard Transformer Company, Warren, Ohio.

(167) SYNCHRONOUS MOTORS—Publication 1012 GHJ, "The Most Efficient Drive in Industry."—Electric Machinery Manufacturing Company, Minneapolis, Minn.

(168) HEATING EQUIPMENT — Folder GEC-81A, industrial heating devices.—General Electric Company, Schenectady, N. Y.

(169) TESTING INSTRUMENTS—Bulletin 195, "The Paragon Megohmer."—Herman H. Sticht & Company, 15 Park Row, New York, N. Y.

(170) HEAT TREATING—Folder, "Proper Heat Treatment of Forgings," and a description of Interstate heat-treating equipment.—Interstate Drop Forge Company, 27th St. and Capitol Drive, Milwaukee, Wis.

(171) CONTROL EQUIPMENT — Catalog GEA-606B, The complete line of industrial control devices.—General Electric Company, Schenectady, N. Y.

(172) ELECTRIC FURNACES—Bulletin 190, "Falcon" continuous electric furnace for heat treating strip metal and wire.—H. O. Swoboda, Inc., 3400 Forbes St., Phila., Pa.

(173) SOLDERING—Booklet, "Facts on Soldering," 36 pages, instructions on the proper methods of soldering and descriptions of the necessary equipment.—The Experimental and Research Department, Kester Solder Company, Chicago, Ill.

Coming Events

American Society of Heating & Ventilating Engineers—Annual Summer meeting, Curtis Hotel, Minneapolis, Minn., June 23 to 25. Secretary, A. V. Hutchinson, 33 West 39th St., New York, N. Y.

American Institute of Electrical Engineers—Annual Summer convention, June 23 to 27, Toronto, Ont. Annual Pacific Coast convention. Sept. 2 to 5, Portland, Ore.

American Welding Society—Annual Fall meeting, Congress Hotel, Chicago, Ill., September 22 to 26. W. M. Spraragen, 29 West 39th St., New York, N. Y.

National Safety Council — 19th Annual Safety Congress, Sept. 29 to Oct. 4. Hotels William Penn and Fort Pitt, Pittsburgh, Pa.

Illuminating Engineering Society —Twenty-fourth annual convention, Hotel John Marshall, Richmond, Va., Oct. 7 to 10, 1930. Society headquarters, 29 West 39th St., New York City.

Fifth Midwest Engineering and Power Exposition — Coliseum. Chicago, Feb. 10 to 14, 1931. Managers Midwest Engineering Exposition, Inc., 308 West Washington St., Chicago, Ill.

INDUSTRIAL ENGINEERING'S DATA SHEETS

Lubrication of Ball and Roller Bearings

IN the operation of ball and roller bearing equipment, proper lubrication is of outstanding importance. The kind and quality of lubricant, as well as the system for applying it, must bear a definite relationship to the design of the bearing, the design of the machine, and the conditions of operation.

The problem of lubricating ball and roller bearings may be stated as follows: (1) To support the sliding contact which exists between the cage or retainer and the rolling elements; (2) to support any contact between the races and rolling elements that is not true rolling; (3) to protect the highly finished surfaces of rolling elements and races from rusting and corrosion, and (4) as a secondary function, to assist the housing closure in excluding dirt or other destructive foreign matter from the bearing.

If the operating temperature of a ball or roller bearing exceeds 125 deg. F., ordinary greases

(Continued on the following page)

OIL LUBRICATION OF BALL BEARINGS OPERATING AT HIGH SPEEDS

Bearing Load* Pounds	Shaft Speed, R.p.m.				
	5,000	7,200	10,000	15,000	20,000
10	Spindle oil	Spindle oil	Spindle oil	Spindle oil	Extra light
25	Spindle oil	Spindle oil	Spindle oil	Extra light	Light
50	Spindle oil	Extra Light	Extra Light	Light	
100	Extra Light	Light	Light	Medium	
200	Medium	Medium	Heavy		
300	Medium	Heavy			
	60 mm.	50 mm.	40 mm.	30 mm.	52 mm.
	Maximum Permissible Shaft Size				

Greases are used under these conditions. The suitability of any particular grease in meeting the requirements of service is best determined by actual trial.

*For thrust loads multiply the actual thrust load by 4, and enter the table with this value of load.

OIL LUBRICATION OF BALL AND CYLINDRICAL ROLLER BEARINGS

Bearing Load Pounds	Shaft Speed, R.p.m.					
	100	300	600	1,200	1,800	3,600
50	Light	Light	Light	Light	Medium	Medium
100	Light	Light	Light	Medium	Medium	Medium
500	Light	Light	Medium	Medium	Medium	Heavy
1,000	Medium	Medium	Medium	Heavy	Heavy	Heavy
2,000	Medium	Medium	Heavy	Heavy	Extra heavy	
5,000	Medium	Heavy	Heavy	Extra heavy		
7,500	Heavy	Heavy	Extra heavy			
10,000	Heavy	Extra heavy				
15,000	Extra heavy	Extra heavy				

Greases may be used throughout the above range provided they are selected to meet the operating temperature of the bearing. The heavier oils are used for the higher bearing temperatures and suitable greases must have a corresponding temperature range. It is suggested that generally a No. 2 grease can be used where a light or medium oil is specified and a stiffer or high-temperature grease where heavy and extra heavy oil is called for.

Courtesy of H. E. Brunner, Chief Engineer, SKF Industries, Inc.

INDUSTRIAL ENGINEERING'S DATA SHEETS

Lubrication of Ball and Roller Bearings

(*Continued from the preceding page*)

will frequently be found unsatisfactory. They will tend to soften and flow continuously into the path of the rolling elements, causing a rise in the normal operating temperature due to the increased frictional resistance introduced and eventually resulting in a separation of the oil and soap base with complete loss of the lubricating qualities. Certain high temperature greases are available, but before using them careful consideration should be given to their suitability for antifriction bearings.

Mineral oil of proper physical and chemical properties is an ideal lubricant for ball and roller bearings when the housing design is properly arranged to control the quantity applied to the bearing, prevent leakage, and protect the bearing from the entrance of dirt or other foreign matter.

The classification of oils given below arranged according to their viscosities as determined by means of a Saybolt Standard Universal Viscosimeter at 100 deg. F., is used in this discussion of lubrication.

Extra light	**135- 165 sec.**
Light	**180- 220 sec.**
Medium	**270- 330 sec.**
Heavy	**360- 440 sec.**
Extra heavy	**450- 550 sec.**
Steam cylinder	**2,000-2,500 sec.**

The viscosity of an oil or the consistency of a grease should bear a definite relationship to the speed of operation of the bearing and operating temperature. When a bearing is run under high temperature conditions, a heavier oil should be used than when the same bearing is run under low temperatures. If too light an oil is used, it may be dissipated from the bearing too quickly by atomizing or evaporation. At high speeds an oil of high viscosity will cause the development of excessive heat; likewise, a grease that is too heavy may channel and fail to lubricate or protect the rotating elements. The charts are offered as a practical guide for properly selecting oils and greases to meet given operating conditions of load and speed. It is especially important to realize, however, that the success obtained from any lubricant depends in a large degree upon the method or system used in applying it. A few drops of oil or a corresponding amount of grease, when properly distributed or dispersed over the running surfaces of the bearing, will provide satisfactory lubrication for a considerable period of time. The presence of a large volume within a bearing, on the other hand, will usually result in high operating temperatures as a result of the working or churning of the lubricant by the rolling elements and retainer and will impair the useful life of the lubricant seriously. This may be through the oxidation or sludging of oil or actual disintegration of greases.

For speeds below 3,600 r.p.m. on horizontal shafts, it is usually satisfactory with oil lubrication to provide a system that will maintain the level of the oil at about the center of the lowermost ball or roller in a bearing. On vertical shafts some form of flinger is usually employed to raise the oil from a reservoir in the bottom of the housing to the surfaces of the bearing, If grease is used, the housing should be not more than one-quarter to one-half full initially.

At speeds above 3,600, control of the quantity of lubricant becomes very important. With oil lubrication, different forms of wick feed have been found convenient and highly satisfactory both from the point of view of regulating the flow as well as filtering any incidental foreign matter that may have gained access to the oil supply.

Grease is being used successfully for the lubrication of ball bearings at high speeds, but in order to obtain satisfactory results, great care is necessary, from the standpoint of both the housing design and the selection of the lubricant. Any system used must provide for a limited amount being fed into the bearing. The extent to which dust, dirt, moisture, or other foreign substances may gain access will influence the frequency with which the lubricant must be renewed. Likewise, the operating temperature and mechanical working of the lubricant by the bearing will affect the useful life of a lubricant. In general, the lubricant can be applied and the housing sealed for a period ranging from three months to a year.

The most destructive agents in limiting the life of an anti-friction bearing are dirt and abrasive materials. If these gain access to the bearing housing, the lubricant should be drained or washed out, the bearing thoroughly cleaned, and new lubricant applied.